DOCUMENT RESUME

ED 223 626 TM 820 314

AUTHOR Blackburn, Mary; And Others
TITLE Science Library of Test Items. Volume Fourteen. Comprehension Testing Program, 2. Part 3: A Manual for Teachers, 2 (Exercises 64-150).
INSTITUTION New South Wales Dept. of Education, Sydney (Australia).
REPORT NO ISBN-0-7240-5865-6
PUB DATE 81
NOTE 142p.; The Library of Test Items series includes ED 218 284-299, TM 820 303-321, and TM 820 892-895. For related documents, see TM 820 306-307, and TM 820 315; Small print throughout.
PUB TYPE Tests/Evaluation Instruments (160) -- Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01/PC06 Plus Postage.
DESCRIPTORS *Diagnostic Tests; Foreign Countries; *Reading Comprehension; *Science Tests; *Scientific Literacy; Secondary Education; Secondary School Science; *Test Construction
IDENTIFIERS *Australia (New South Wales); *Test Manuals

ABSTRACT

A set of 87 science exercises annotated for teachers and designed for diagnostic and formative testing are presented with a description of the purposes of the comprehension testing program. The exercises are meant to develop skills in processing scientific information through critical reading skills development. The annotations suggest how teachers may use a range of passages and questions to test vocabulary, content, inference, and conceptual comprehension; attitude acquisition; and creativity skills. Skill areas needing further development can be identified. The exercises were written by teachers and were reviewed and pretested for students in grades 7 through 10. (CM)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED229826

New South Wales **Department of Education**

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

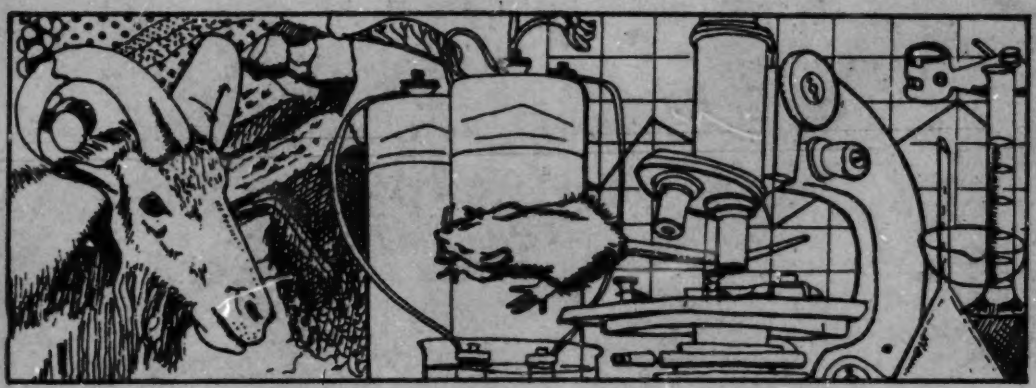
SCIENCE

LIBRARY OF TEST ITEMS

Comprehension Testing Program-2

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
J. Cook
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

PART 3 : A MANUAL FOR TEACHERS – 2
(EXERCISES 64 – 150)



TM 820 314

VOLUME FOURTEEN OF THE SCIENCE LIBRARY OF TEST ITEMS

The content of the Science Library of Test Items project, of which this is Volume Fourteen, is as follows:

Volume One:	A collection of multiple choice items
Volume Two:	A second collection of multiple choice items
Volume Three:	Introduction and Manual to Mastery Testing
Volume Four:	The Practical Testing Guide
Volume Five:	Readability and Science Testing
Volume Six:	Comprehension Testing Manual
Volume Seven:	Print Masters for Comprehension
Volume Eight:	Series 3 & 4 Supplement to Mastery Testing
Volume Nine:	Mastery Tests Series 1 (M1 - M13)
Volume Ten:	Mastery Tests Series 2 (M14 - M26)
Volume Eleven:	Mastery Tests Series 3 (M27 - M38)
Volume Twelve:	Mastery Tests Series 4 (M39 - M50)
Volume Thirteen:	Mastery Tests Series 5 (M51 - M65)
Volume Fourteen:	Comprehension Testing Manual - 2
Volume Fifteen:	Print Masters for Comprehension - 2

The following volumes are in various stages of production and should be finalised by the end of 1981:

Volume Sixteen:	Mastery Tests Series 6 (M66 - M80)
Volume Seventeen:	Biology Test Items
Volume Eighteen:	Physics Test Items
Volume Nineteen:	Chemistry Test Items
Volume Twenty:	Geology Test Items
Volume Twentyone:	Processes in Science Test Items
Volume Twentytwo:	Mastery Tests Series 7 (M81 - M95)
Volume Twentythree:	Mastery Tests Series 8 (M96 - M110)

All material in the project is made available in the hope that teachers will select those parts which are of use to them in developing their own testing programmes.

ISBN-0-7240-5865-6

Comprehension Testing Program-2

PART 3 : A MANUAL FOR TEACHERS – 2
(EXERCISES 64 – 150)

TESTS OF SKILLS REQUIRED IN PROCESSING SCIENTIFIC INFORMATION

PRODUCED BY SCHOOL CERTIFICATE DEVELOPMENT UNIT, DIRECTORATE OF STUDIES

1981

ACKNOWLEDGEMENTS

As with all projects of this type, many people offer material, advice or comments, and some work on the actual production team.

Most of the passages used in this volume were found or written by the following, who were also part of rewviewing and production work groups.

Mary Blackburn - Westfields
Kim Fillingham - S.C.D.U.
Mike Gunnourie - Sydney T.C.
Brian Jarman - Turramurra
Jackie Keith - Dulwich
Peter Macinnis - Sydney Tech.
Kevin Molyneaux - Cabramatta
Di Nicol - Strathfield
Brian Shadwick - Riverside
Jim Stamell - Teaching Resources

The annotations in this manual were, in part, written by the production team, but come mainly from the mind (?) of Peter Macinnis. As was the case with the first volume of comprehension, many other teachers gave advice and comments on the material as it was being produced. To all these people our appreciation.

We would particularly like to thank those teachers who provided feedback on the implementation of the exercises in schools.

We appreciate this kind of comment and would like you to keep those cards and letters rolling in.

This is the second volume of comprehension exercises produced the Science Library of Test Items, the first being produced early in 1980 and containing 63 exercises.

The 87 exercises in this volume are in the same format as the first, most of them being written at about the same time. Therefore, the style of the passages has not altered, which you may consider good or bad. This volume intends to extend the range of exercises available to teachers.

Some schools are known to be writing their own material, particularly since the publication of the Reading K-12 document. We would be pleased to receive copies of any material which might be of benefit to others, and which might stimulate our production team. More importantly, we would be delighted to broaden our vistas and incorporate an even wider range of teachers in our writing team. You could become part of this team by sending contributions to:

Subject Officer (Science),
School Certificate Development Unit,
Directorate of Studies,
Department of Education,
P.O. Box 33, G.P.O.,
SYDNEY N.S.W. 2001

We hope, during 1981, to produce a third volume of comprehension exercises which are more suitable for the slower readers. Any suggestions or offerings of material suitable for inclusion in this volume would be particularly appreciated.

What is available?

Every school in N.S.W. which has students in any of Years 7 - 10 is to receive *one* copy of the "print masters" of the exercises shown in this manual. The print in these masters is full size, while the copies in this manual are reduced by 25% to allow room for notes.

This manual has been printed in sufficient quantities to allow four copies to be issued to each High School, and two copies to each Central School. Principals may apply for further copies should they have more staff desiring copies of the manual than they have available copies. Requests should name the teachers who have received copies, and the teachers who are

to receive the requested copies. Requests should be addressed to:

The Chief Services Officer,
School Certificate Development Unit,
Directorate of Studies,
Department of Education,
Box 33 G.P.O. SYDNEY N.S.W. 2001

What do these exercises test?

Purists may shudder at the use of "comprehension" to label these exercises. And yet, if they were to look at exercises given in English classes, they would be hard-put to distinguish the one from the other. The content of the passage might help, but the nature of the exercises would not:

The questions cover a range of types:

1. Vocabulary Items: either inferred from the passage or to be looked up in a dictionary.

Example 1: What is the meaning of polymorphous (line 3)?
Example 2: Polymorphous (line 3) means

A. many-sided. C. many-edged.
B. many-shaped. D. many-pointed.

(Note that in this form, the item tends to direct the student to the assignment of the meaning "many-" to "poly-". This is acceptable in take-home-and-look-up-testing: in fact, it is desirable. If this were to be used in a ranking test, it might be thought necessary also to test the student's knowledge of the meaning of "poly-".)

Example 3: Polymorphous (line 3) means

A. many-shaped. C. single-shaped.
B. many-sided. D. single-sided.

(This, while C and D are inelegant, tests the student's knowledge of the meaning of "poly-" and also of "-morphous".)

2. General Content: in this area, we move from the level of the individual word to the level of meaning detected at or about the sentence level.

Example 4: in the first sentence, what are the "customary procedures" mentioned by Darwin?

(This would be any of free-response, matching form or multiple choice.)

3. Inference: here, the level of comprehension approaches the paragraph level, or may even pass it.

Example 5: from the available evidence, in which season did Darwin visit Australia?

A. Summer. C. Winter.
B. Autumn. D. Spring.

(This could present problems, especially in a take-home test, since the relevant chapter of "The Voyage of the Beagle" is dated January 12th 1836. It may be necessary to ask for a listing of the evidence, which would probably be of greater pedagogical value anyhow.)

4. Big Ideas:

Example 6: in passage 9, what does Darwin mean at the end of the passage when he asks "... can any mountains, any continent, withstand such waste?"

5. Tone adopted by the writer: this will not always be possible, but terms such as persuasive, sarcastic, angry and informative come to mind. It is probable that reasons would need to be given for a student's choice.

Example 7: the tone adopted by the author might be described as angry, ill-mannered, or sarcastic. Indicate which of these terms (or any other of your choice) you feel would be most suitable, and give your reasons for your choice (or choices).

The purpose behind this production

This collection is intended to serve a number of different ends, some of which are indicated in the opening lines of this introduction. But consider this:

There would appear to be a strong band of opinion which says that "standards" are falling. Many teachers object to this bald assertion, since it usually comes from a comfortably data-free position. What all teachers accept is that standards are not as high as they would like. It is with this in mind that we offer this as one way of developing skills of reading and communication with a science bias.

Testing is far more valuable to us and our ability to maintain our standards if it tells us something about a student's likely performance in real life. The material being produced in this program is planned to identify student problems in *critical reading*. We hope, in this way, to produce students who are more literate in science, as well as being more scientifically literate.

A *critical reader* is one who should be able to:

analyse,
look for evidence,
withhold judgement,
recognise bias, and
distinguish logical reasoning from emotional appeal.

In other words, we are trying to develop students who can do all those reading things which they will need as basic survival skills in the Big Bad World.

Now it just so happens that many other school subjects aim to achieve the same ends. We hope that what atudents learn in science will transfer to those other subjects, and *vice versa*. But if other subjects are aiming to these ends, why should science teachers become involved? Why not leave it to those other subjects?

We are not unmindful* of the possibility that students may gather together an assortment of scientific facts while "doing" science comprehension exercises, but this is not our main aim. What concerns us far more is the need to develop students' abilities to deal with scientific information. While students who carry out a number of exercises such as those proposed will develop their processing abilities, we are more concerned to identify *those skills which a student does not possess*, so that teachers can help their students. We are in the business of making stethoscopes, not cure-all drugs. If, however, a student is cured by his (or her) taking a stethoscope with water three times a day before meals, we shall count that as a not-altogether-unexpected-event, and rejoice mightily.

---

* To emulate Watson and Crick

In fact, we can even produce a name for what we are doing, a name which may be found in all the best educational journals, and which may safely be mentioned at meetings with parents-who-also-just-happen-to-be-lecturers-in-education. We are writing tests which are *diagnostic* and *formative*. They diagnose faults which need remediation, and at the same time, they help the student to indulge in self-remediation. We will return to this point shortly.

Among the side-effects which could be expected, the passages which have been used come from a range of sources, and reflect a number of different interests. We would hope that in this way we may broaden students' conceptions of both science and of sources of scientific knowledge.

We have not hesitated about asking questions which, strictly speaking, are not within the "proper" boundaries of science. Etymology, calculations, and the origins of quotations are but three areas which may be claimed by other disciplines. We would be delighted if the transgressed-upon disciplines should "retaliate" by crossing our boundaries in turn: it is our view that to withdraw within disciplinary boundaries is to risk leaving ground uncovered, the very ground wherein may be seen the inter-linkings between the disciplines.

The practising teacher may well feel that some of the material is not suited to his/her classroom and class. We would be surprised indeed is this were not the case. If teachers look on some of the material, especially the sections labelled "Research questions" as sources of, for example, follow-up library assignments, they may be a little less concerned. This point needs stressing:

> THIS MATERIAL IS INTENDED TO SHOW THE RANGE OF TESTING WHICH IS POSSIBLE. IT IS NOT THE DEFINITIVE STATEMENT ON WHAT SHOULD BE TESTED.

And now we can offer another hifalutin' claim: this Unit must, by its nature, subscribe to a policy of educational pluralism. Put more plainly, we must supply something for everyone, so far as the limitations of a given medium allow. It follows from this that any given program will contain elements which will be found unsatisfactory by some teachers. We might even argue that no truly professional teacher should agree with everything we do.

The questions which have been developed include the testing of some components of attitude acquisition, creativity, and even drawing skills. This range is justified in our view by the view that if teachers believe in developing and/or fostering an attribute, then it is proper for them to consider testing changes in that attribute.

TWO IMPORTANT WARNINGS:

1. As has already been pointed out, this material is designed for diagnostic and formative testing. The questions have been written with this approach in mind, and so will generally favour that approach. As a result, teachers who use the test responses to rank students from "top" to "bottom" may be doing some students an injustice. Our concern is to identify faults in need of remediation, so that we were not and are not troubled by the question of "test-witness". If a "test-wise" student uses the statement of one question to work out the answer to another question, this is merely one aspect of the ability to draw correct inferences. It would be likely, in such a situation, that the student in question would "self-remediate" (learn the answer) while drawing the inference, so that teacher remediation would not be needed. Test scores would reflect the situation at the end of the test, rather than that at the start of the test.

2. There is also the problem of copyright. Much of the material to be reproduced here is restricted by copyright. It may be relevant to consider this excerpt from the Copyright Act, 1968:

> "200 - (1) The copyright in a literary, dramatic, musical or artistic work is not infringed by reason only that the work is reproduced or, in the case of a literary, dramatic or musical work an adaptation of the work is made or reproduced -
>
> * * * * * *
>
> (b) as part of the questions to be answered in an examination, or in an answer to such a question."

It is in this context that this copyright restriction is given with respect to the samples which are included here:

> This collection is intended for use in schools in the course of educational instruction. To comply with the laws of copyright, no part of this publication is to be used for any purpose other than as part of an examination or test.

The same restriction will be repeated when the main collection is released.

About the passages

A number of readability measures were toyed with. In the end, our own private version of SMOG* was used to produce a four-star rating system as follows:

Number of Stars	Recommended Student *reading ability*
ONE	Years 5, 6, 7, 8
TWO	Years 8, 9, 10
THREE	Years 10, 11, 12
FOUR	Year 12 and above

It is hoped that teachers will recognise this for what it is: A ROUGH GUIDE ONLY.

Passages have been altered in some cases for reasons such as:

* variations in spelling: in general, American spelling such as *mold* and *maneuver* have been replaced by *mould* and *manoeuvre*. The IUC-preferred *sulfate* has been used instead of *sulphate* wherever it appears, since this appears to be the pattern of the future.
* correct SI usage has been inserted: there are no commas in large numbers, mL is used in place of ml, and so on. In some cases, little remains of the original, other than the original meaning.

In such a case, as in several cases where the source is a dog-eared cutting from a scrap-book, no source is indicated, since one cannot fairly be given. Where it is possible we have given the source, so as to show students the range of available "science reading", and also to help teachers who wish to seek further passages from the same work.

Additionally, some passages have been rewritten to improve "readability" as measured by the normal means. Such a rewriting does not affect content suitability for students.

---

* See "Readability and Science Testing", S.C.D.U., 1979.

HOW TO SELECT FROM THE OFFERINGS

The passages and questions are not proposed to supply the basis of an intensive course in scientific comprehension. They are intended to be introduced as and when they suit a course. As an example, one passage (number 61) deals with the "Heimlich manoeuvre", a means of dislodging objects caught in the trachea and causing choking. This particular procedure is not approved by Australian first-aid bodies, but it involves a manipulation of the diaphragm. It would thus be relevant to, and of interest to, a class "doing" respiration. But before it is used, the teacher must ask:

* Is this passage suitable for my class?
* Are the questions suitable for my class?
* Are there any other questions which could be asked?
* When will the work be done: at school or at home?

(It is suggested that "take-home" tests could be used far more than is the present case.)

* Should my students do all (or any) of the "Research questions" section?

Teacher selection will be aided by the index at the end of this Manual. The index lists "key" words which will help in three ways:

(i) If a teacher has previously seen a passage, and recalls what it is about, the index will help rapid location. This will become more important when the full collection is released in early 1980.

(ii) If a teacher wants other related passages, the annotations in the manual will help, by giving cross-references. The addenda at the back of this manual, if incorporated into the annotations in Volume 6 (exercises 1-63) will serve to cross-reference these exercises to those in this volume.

(iii)Teachers wishing to use these exercises on a regular basis may wish to "tie in" with the themes being taught at a given time. The index will help here.

How should the exercises be used?

In many cases, teachers will feel that certain questions are unacceptable to them. They may have the question section re-typed to avoid the "offending" questions, or simply tell students to ignore some questions. Our aim has been to demonstrate a range of questions for each passage, and we are quite happy to see changes.

A number of teachers have indicated that they would not record marks, but would use the exercises as a basis for class discussion: students would read the passage and do specified questions overnight as a preliminary to a lesson on the following day.

Another group sees some of these exercises as useful for the unprepared and often untrained (in Science) casual relief who fills in for unexpected absences. They may certainly enable all relieving staff to teach something "scientific".

Dear reader,

The annotations in this manual are offered as "starters". We hope that you will add your own notes to ours, but we also hope that we have "broken the back" of this task for you. Because we have aimed to cover the byways as well as the highways, you will find unnecessary trivia, and excessive detail. Please bear with us, and pass on to the next matter: <u>that</u> side-track was for someone else.

The "content" to be found in the following pages shows a distinct and deliberate bias. This is because we tried to exhaust certain areas, thus allowing a better initial cross-referencing. Further releases will redress somewhat the imbalance which is reflected in these pages ....

SOURCE: Life Science Library - "Energy" ★★

EXPANSION 64

Expanding hot gases drive the pistons in an engine and move a car. Solids and liquids also expand when heated. The amount of expansion for each degree of temperature increase depends upon the substance. For example, because the thermal expansion of metal or plastic is different from that of glass, housewives often run hot water over metal covers of food packed in jars, or on the plastic tops of nail polish bottles. This act of heating the lids causes the metal or plastic to expand, loosening the grip on the container. By the same token, heat tends to make metal pendulums of clocks longer. Therefore, grandfather clocks, unless corrected, run slower in summer than in winter.

Expansion is of great technological importance because it frequently causes engineers to provide necessary allowances for many structural materials. A kilometre of railway track, for instance, expands as much as 60 cm in summer heat. So too, a 300 metre metal bridge may change its length by 20 centimetres. At the same time as the road bed is expanding, supporting uprights lengthen. Unless allowances can be made for this, a bridge road would buckle considerably.

These may be problem connectives!

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article? thermal (line 4), pendulum (line 9), technological (line 11), structural (line 12).

2. Why can lids be more easily removed from jars by running hot water over them? See line 4

3. What could cause bridges to buckle in summer? Line 16

4. (a) What is thermal expansion (line 4)? This is intended to elicit EITHER a definition or an explanation.

   (b) Place these substances in order of decreasing thermal expansion.
   (i) glass (ii) metal (iii) plastic This may be debated!
   2 1 3

5. Grandfather Shadwick shifted from Darwin to Melbourne, taking his grandfather clock with him. Would his clock run faster, slower, or keep correct time? Support your answer using evidence from the passage. Faster

6. What does by the same token (line 8) mean? Another problem connective.

RESEARCH QUESTIONS

7. The average length of a section of railway track is about 20 metres.

   (a) How many lengths are there in one kilometre of track? 50

   (b) What gap must be left between each section to make allowance for the expansion mentioned in the passage? 12 mm

8. (a) What allowances are usually made for expansion on large metal bridges? (e.g. Sydney Harbour Bridge). Interlocking toothcomb grilles and hinges

   (b) Draw a diagram to show what this looks like.

9. Describe 3 other situations where an allowance must be made for thermal expansion. Give 1 example each for a solid, a liquid and a gas.

10. Thermal expansion can also be used to man's advantage. Describe, using diagrams where necessary 3 uses man makes of (differing) thermal expansion (one each for gases, liquids and solids).

9(i) Electricity wires between poles,
(ii) In reverse: allowance for water expansion on freezing
(iii) Pressure release valve on a pressure cooker.

10 (i) Bimetal strip thermostats,
(ii) Thermometers, oil globule in lamps (popular kitsch of the 1950s,
(iii) Steam engines.

We hope you can find some more examples.

See also exercise 63

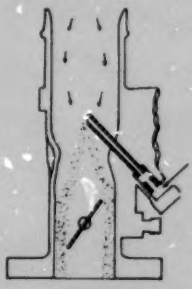
★★

SOURCE: Adapted from C.M. Tempest "Automative Service Technology" Book 1, Sydney, Angus and Robertson, 1966 pp.60-62

THE CARBURETTOR 65a

The carburettor, such as that used in a car, is a measuring instrument which provides properly proportional combustible mixtures of atomized fuel and air to suit engine requirements over a wide range of speeds and loads.

A simple carburettor consists of a short length of tube with a restricted section, a fuel nozzle, and a disc or butterfly-type throttle valve. The main tube is called the *air horn*, the restricted section is the *venturi*, and the valve is known as the *throttle valve*. The venturi causes an increase in air speed at the small diameter, and due to its special shape as it opens out again a partial vacuum is produced in the venturi.

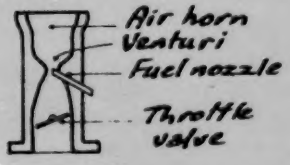


The greater the air speed, the greater the flow of fuel from the *fuel nozzle*. The opening and closing of the throttle valve increases or decreases the flow of fuel mixture to the engine and thus controls its speed. When the valve is open the flow is maximum and when closed the flow of fuel mixture is minimum.

Do not write any answers on this sheet. All answers are to be written on your own paper or in your book.

1. What do these words mean, as they are used in the article? proportional (line 2), combustible (line 2), atomized (line 2), partial (line 17).

2. Copy this diagram of a carburettor into your books and on it label the arrows using the words: *venturi, air horn, throttle valve, fuel nozzle.*



65b

3. The carburettor that you have just drawn shows the throttle valve in a certain position. In this position a car would most likely be travelling at about

A. 0 kilometres per hour. C. 30 kilometres per hour.
B. 15 kilometres per hour. D. 45 kilometres per hour.

4. Below are 3 diagrams of the main component of a carburettor. On the diagrams draw the position of the throttle valve of a car moving at 40 kph, 80 kph and 120 kph respectively.

5. What instrument, operated by the driver of the car, would control the throttle valve? Accelerator pedal

6. What causes the fuel to be drawn up the fuel nozzle? Reduced pressure

7. (a) What is the relationship between the speed at which the air moves through the venturi and the rate at which fuel flows out of the fuel nozzle? *

(b) What does this indicate about the air *pressure* in the vicinity of the venturi as the air *speed* increases?

RESEARCH QUESTIONS

8. The effect which makes the carburettor of a car work was first expressed in mathematical form by Daniel Bernoulli in 1738 and is called *Bernoulli's principle* or the *Bernoulli effect*. What, in simple terms, is the Bernoulli principle? The pressure of a fluid moving in a pipe is least where the velocity is greatest.

9. In about a page of writing find out about the life and work of Daniel Bernoulli. What were his major contributions to science? 1700-1782. Should not be confused with his uncle, father, brothers, cousin or nephew - see Asimov's Biographical Encyclopaedia.

10. An atomizer and the lift on an aeroplane wing also use Bernoulli's principle. Find out how these work. Use diagrams, appropriately labelled, to illustrate your answer.

11. Find out some other cases where the Bernoulli principle is used. Old-fashioned fly-spray, some hose-operated garden sprays, air-brush, paint sprayers.

12. One we did not ask because we don't know: who was Venturi?

*7a: The sum of the pressure, potential and kinetic energies is constant: so the velocity increases, therefore, the pressure is reduced.

7b: The pressure is less.

See also exercises 48, 63, 64, 67, 68, 148

This passage escaped the eagle eye of our resident compulsive Anglicizer.

SOURCE: Life Science Library - Energy.

★★

66a

CHANGING STATE

In his pioneering research on heat, Joseph Black used the thermometer to study many things which had previously defied understanding. To his predecessors, it had seemed logical that a kettle of water kept on a stove would get hotter and hotter. In boiling it should continue to increase in temperature until all the water boiled away.

Black established that water ceases to get hotter after it has reached 100°C but it still boils away. Black also established that a mixture of ice and water remains at the same temperature, though heat may be added or lost, until it changes entirely to ice or water.

In observing ice melting into water and water vaporizing into steam, Black recognized that heat was necessary for these changes. His conclusion was that water in the form of ice stays solid at 0°C because it lacks a sufficient amount of heat to change itself into a liquid. He further concluded that water never becomes hotter than 100°C because at that temperature it completely takes in all the heat that is available in the process of changing itself from a liquid into a gas. In the reverse process when water changes from a liquid to a solid or a gas into a liquid, Black hypothesized the presence of what he called "latent heat". In order for water to freeze, he reasoned the latent heat was to be taken out.

"My conjecture, when put into form, was to this purpose," Black wrote, "I imagined that, during boiling, heat is absorbed by the water, and enters into the composition of the vapour produced from it. In the same manner heat is absorbed by ice in melting, and enters into the composition of the produced water."

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? pioneering (line 1), predecessors (line 3), vaporizing (line 10), sufficient (line 13), hypothesized (line 18), conjecture (line 21), absorbed (line 22).

2. What observations led Black to hypothesize that substances contain *latent heat*? Lines 6-9

WHOOPS! *

3. Using your dictionary, find the meaning of the word 'latent'? What does latent heat mean (line 19)? Why is the word latent an appropriate word to use in this context?

* The reduced copies on which these comments are written contain a number of errors which have been corrected for the student copy. The comment WHOOPS! means we have seen and corrected the error. Or at least that we have seen the error - correction is a separate process.

RESEARCH QUESTIONS 66b

4. What is the difference between temperature and heat?

5. Indicate whether latent heat is absorbed or lost in the following changes of state:
   (a) ice melting
   (b) water freezing
   (c) butter melting in a frypan
   (d) water changing into steam
   (e) gas condensing to a liquid.

TRY THESE ON YOUR CLASS!
How much of the butter really melts? Can butter freeze?

6. We make use of latent heat in several appliances. Name two appliances which rely on latent heat for their operation and describe how they work. Steam radiator, refrigerator, air conditioner, water bag, Coolgardie safe....

7. Explain the following observations in terms of the idea of latent heat:
   (a) perspiration cools you down.
   (b) wet newspapers, wrapped around cans of drink, keep the cans cool on a picnic.
   (c) a cold day becomes warmer if it starts to snow.

7(c) should cause some debate - some will argue that this is a relative effect. Why not trot out that old prac with buckets of warm, tepid, and cold water?

See also exercises 66 and 68.

★★★

SOURCE: Understanding Science

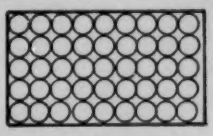
STATES OF MATTER 67a

The three states of matter are solids, liquids and gases. We are used to thinking of some things as solids, and of others as liquids, even of a few as gases. We *know* which are which.

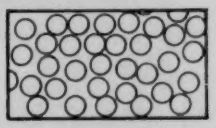
But we are only right within the temperature range in which we live. Lower or higher temperatures cause matter of every sort to change its state.

Copper, which we think of as a solid, can be changed into a liquid or a gas. Hydrogen, which we think of as a gas can be changed into a liquid and even a solid. Of course, we are unlikely to see these changes as the temperatures needed are very extreme. However, the changes can occur.

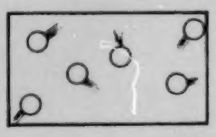
The smallest possible piece of any material is an atom. The difference between solid, liquid or gaseous states is the amount of movement the atoms and the molecules (groups of atoms) make.



In the solid state, the atoms or molecules are packed closely together. They do not move about. They just vibrate back and forth while staying in fixed positions. This makes it difficult to press solids into new shapes.



In the liquid state the molecules are just as close together, but they can roll past one another. The hotter the liquid is, the faster the molecules move. Because the molecules can move like this so easily a liquid has no fixed shape, in fact it always fits the bottom of whatever contains it.



It is difficult to believe that a solid metal can actually turn into a gas. However, at very high temperatures the atoms of the metal move so fast that they break away from each other and form into the gaseous state. They then move freely and take up a great deal more room than as a solid or a liquid. There is a lot of space between each atom. It is therefore easy to compress a gas. It is just a matter of reducing the space between the atoms. Like a liquid, a gas has no shape, but unlike a liquid it will spread out to fill its container completely.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?

   temperature (line 4), range (line 4), material (line 12), vibrate (line 17), compress (line 35).

Resumés of paras 5, 6 & 7 needed here.

2. What makes solids, liquids and gases different from each other?

3. What words are used in the passage to describe the way the atoms or molecules in (a) solids, (b) liquids and (c) gases move?
   move freely vibrate roll past

4. Why is it that gases can be compressed, while liquids and solids can not be compressed?
   See lines 34, 35 and 36.

67b

5. In paragraph 3, changes in copper and hydrogen are mentioned. State, for each of the changes mentioned whether the temperature has to rise or fall for the changes to occur.

6. The last paragraph mentions that a gas will "spread out to fill its container completely". What one word in science describes this process? Diffusion (see Q 7(v))

7. Explain the following things about solids, liquids and gases in terms of the way their atoms or molecules are arranged and can move.
   (i) gases can be compressed.
   (ii) solids have a fixed shape.
   (iii) gases occupy all their container.
   (iv) liquids can be poured.
   (v) solids do not diffuse. – At least in the sense used in this passage: see Q. 6.

RESEARCH QUESTIONS

8. What one word name is used to describe the following changes?
   (i) solid → liquid. melt
   (ii) liquid → gas. boil
   (iii) solid → gas. sublime *
   (iv) gas → liquid. condense
   (v) liquid → solid. freeze
   (vi) gas → solid. sublime *

9. (a) What is the difference between an atom and a molecule? Use diagrams to help your answers.

   (b) What is an element?
   What is a compound?

   (c) What is the difference between the molecule of an element and the molecule of a compound? Use diagrams if you wish.

10. (a) What is the temperature range for
   (i) Sydney.
   (ii) The Snowy Mountains.
   (iii) The Nullarbor Plain.
   (iv) Darwin?

   (b) In which of these places would you be most likely to find water as (i) a solid.
   (ii) a liquid.
   (iii) a gas.

10(a)(i) 2°C - 45°C (Observatory)
(ii) -11°C - 40·7°C (Cooma)
(iii) -35°C - 47·2°C (Cook)
(iv) 13·3°C - 40·5°C

(b)(i) Cooma (but they sell lots of ice in Darwin....).
(ii) All.
(iii) Wherever the billy boils.

* Sublime has two separate, relevant, meanings. See the "Shorter Oxford" (your school library should have one). Read meanings 3a and 3b.

See also exercises 63, 64, 66 and 67

WARNING! Do you know the significance of a four-star passage?

SOURCE: Life Science Library - "Energy"

★★★★

BOILING 68a

The surface of a liquid such as water, acts as a sort of barrier to the outer world. For instance, a molecule below the surface, travelling upwards at a high velocity, may pass out of the liquid into the atmosphere. To do this the molecule must do work against the surface as well as against air pressure. Only when the temperature is high enough does the average energy of the liquid allow an appreciable escape of molecules into the atmosphere.

The fastest molecules escape as heat is added. They break through and away from the surface. They transfer some of their energy to the atmosphere. As the heat applied to the liquid continues, more and more molecules attain speeds which enable them to escape through the surface. When enough of the molecules reach this point, the surface of the liquid becomes quite violently agitated. The liquid boils.

At the boiling point each addition of heat energy is divided among the molecules left behind in the liquid. Eventually, their speed rises until they, too, can escape. In other words, a steadily heated liquid rises in temperature to a certain point at which the temperature becomes constant while the liquid boils away.

Kinetic theory explains this process as a matter of increasing the velocity of each molecule to the point at which its kinetic energy is sufficient to break free from the attractive forces of each neighbouring molecule.

At this point, a change of state occurs. The liquid becomes a gas. The energy used up in the process of changing state is called latent heat.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article? molecule (line 2), agitated (line 13), process (line 19), latent (line 24).

2. What do the following terms mean as they are used in the article?
average energy (lines 5 and 6), boiling point (line 14), kinetic theory (line 19), kinetic energy (line 20), attractive forces (line 21), change of state (23).

At the risk of labouring the obvious, are your students ready for this distinction? May we remind you that the questions offered are a menu: you don't have to consume the lot, and you may even prefer home-cooking!

3. (a) The terms velocity (line 3) and speed (line 11) are commonly used to mean the same thing. However in science they have distinct and different definitions. Define each as it is used in science.

(b) In this article, are the two words used in their common or scientific senses?

4. What has to happen before a molecule of a liquid can escape from the liquid? Must gain enough energy

5. What happens to the additional energy added to a liquid after it starts boiling? Carried off by escaping particles

6. (a) What is the difference between a molecule and an atom? You may need to cite cases of monatomic molecules...
(b) Why does the writer of the passage refer to molecules and not to atoms?

7. What process is being referred to in line 24)? Boiling

8. Rewrite the second last paragraph which starts "Kinetic theory explains .... " in your own words.

RESEARCH QUESTIONS 68b

9. The article refers to attractive forces (line 21). These differ in type, or in strength from molecule to molecule. Write notes to explain how these forces affect the boiling point of a liquid.

10. (a) List these substances in order of decreasing attractive forces between their molecules.
water, alcohol, mercury, ether, iodine, carbon dioxide, oxygen and sugar.

(b) How did you decide on this particular order?

Boiling point order could be a part of it!

See also exercises 67, 73.

★★★

ENERGY CHANGES

69a

The interchangeability among its various forms is one of the most important properties of energy. Physicists can imagine *no* exception to the statement that any form of energy can be converted into any other. Sometimes the conversions seem a little awkward and roundabout. For example, we do not ordinarily try to change mechanical into heat energy directly. Yet it can be done - easily. Rubbing two sticks together generates enough heat to start a fire. Similarly, it is almost impossible to convert heat directly into electrical energy. Instead, man uses heat to run a turbine and the mechanical energy of the turbine will spin a generator to "create" electricity.

Thermocouples, but Arthur C. Clarke has postulated a full-scale version. Well he was the first to suggest communications satellites....

Because the intervening mechanical step is expensive and inefficient engineers are seeking breakthroughs in technology which will convert heat *directly* into electricity. Devices to do this already exist but only on a laboratory scale. Light offers another thorny problem in conversion.

Although a limitless amount of radiant energy falls on the earth every day and is "wasted", man has no truly efficient way to capture this energy for work. Only the green plants of the earth are able to do it on any large scale, although promising man-made devices are coming into use.

Perhaps the most difficult of all the transformations is that from any other form of energy to nuclear energy. It does occur, but the atomic physicist is the only one to witness the transformations. For example, in one very delicate laboratory experiment, light has been observed turning back into the substance of the atom. However, even that one transformation is enough to satisfy a physicist. All other forms of energy can be turned into light and all of them conceivably could be put into a nuclear form.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?

   interchangeability (line 1), properties (line 2), converted (line 3), generates (line 7), turbine (line 9), generator (line 10), intervening (line 11), efficient (line 16), transformations (line 21).

Heat → electrical, Light → electrical, Any form → nuclear

2. Several energy changes are listed in the passage as being fairly difficult to accomplish. List them.

3. Briefly describe how man produces electrical energy.

4. (a) Explain why the word "wasted" (line 16) has been placed in inverted commas. Not used by humans, or not directly. (b) Is "create" (line 10) the correct word to use in this context? Explain. Write down one other word which describes what is meant by "create". Generate

5. What scientific law does this article describe? Write this law out in full. Conservation of Energy

One positive example establishes a possibility. Ascertainty is harder to come by...

6. What is meant by the sentence "However, even that one transformation is enough to satisfy a physicist."

7. This article mentions physicists, technologists and engineers. What does each of these people do? Compare and contrast their roles.

8. The passage uses 6 different terms all saying that one form of energy can be changed into another. Find them.

7: converted (3), change (5), "create" (10), capture (16) (maybe), transformation (19), turning ... into (22-23), put into (25)

8: (Our consensus)
Physicist: basic, pure research;
Technologist: applies research to practical situations;
Engineer: perfects devices for use in practical situations.

RESEARCH QUESTIONS 69b

9. Why do scientists consider the Law of Conservation of Energy an important principle in Science?

10. Man is starting to harness solar energy - not economically yet, but it is a start. Explain, using diagrams where necessary, how either a solar cell, or a solar hot water system works. See exercises 45, 46 and 72

11. Some recent solar energy devices include a solar barbecue. Find out how and why this works, and see if you can build a simple solar barbecue using an old tin can.

9. Well, to put it another way, how much of our science could proceed without this Law? Try exercise 133 — if energy could be created, what price perpetual motion?

See also exercises 60, 71, 82, 95, 145 & 146.

★★

ULTRA VIOLET 70

In 1801, the German scientist Johann Ritter found that at the violet end of the spectrum were invisible rays which were especially effective in promoting chemical reactions. Ritter's discovery came to be called the chemical spectrum. The exact nature of this spectrum did not become known through scientific investigation. Rather, it was examined as a result of a highly commercial invention - photography. In 1839, the Frenchman Louis Daguerre popularized a process for taking pictures on metal plates coated with silver salts.

Science soon capitalised on Daguerre's process to make spectral photographs. Beyond the violet band, a whole new section was recorded on the silver plates. It was invisible to the eye, and named "ultra-violet" (UV).

The human skin also reacts to UV radiation. UV is the part of sunlight which causes sun-tan. Biologists have established that uncontrolled UV rays kill the cells of pure white skin. The white man's slowly acquired sun-tan and the permanent pigmentation of the dark-skinned races serve as effective UV filters. These protect the body cells from damage by the rays which are present in sunlight.

The effects of UV, however, are not all bad. It helps the body make vitamin D. It is used as the so-called "black light" that causes special luminous signs to glow in the dark. Discos use UV lights for special effects - it makes white clothing, in particular, glow superbly.

Home sun-tan lamps use special quartz glass and contain a little mercury. When the electric current vaporises the mercury, the resulting glow contains UV. Quartz glass must be used as ordinary window glass is opaque to UV. This is familiar to anyone who has tried to get a sun-tan through a closed window.

1,25 Dihydroxycholecalciferol
(one of the most active forms of vitamin D_3)
-after Orten & Neuhaus, Human Biochemistry, 9th ed., Mosby, 1975.

9. "Vitamin D" is a group of formulae with structures like the one shown in the sketch. They are produced by energising provitamins from food. Involved (probably) in regulating calcium and phosphate levels. Was a control on intestinal absorption. A deficiency causes rickets, a disease involving inadequate and deformed bone growth.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article?

   spectral (line 9), band (line 10), established (line 13), pigmentation (line 15), luminous (line 20).

2. Why was Ritter's discovery called the chemical spectrum (line 4)?

3. Give 3 properties of UV radiation as mentioned in the passage.
   See lines 10, 13, 19 & 20.

4. If UV was discovered in 1801, why wasn't it analysed until after 1840? Had to wait for photography.

5. What are spectral photographs (lines 9 and 10)?
   Photographs of spectra (not spectra of photographs!)

RESEARCH QUESTIONS How are your students on second dimension neuter plurals?

6. There are two types of spectral photographs used by scientists today: emission spectra and absorption spectra. Briefly describe each and their differences.

7. What have "blue beads of bleach" found in some washing powders to do with "black lights" used in discos?

8. How does pigmentation (line 15) protect skin from UV radiation?

9. What is vitamin D (line 19)? How is it made and what purpose does it serve in our bodies?

6. Emission spectra arise when "excited" electrons "jump" down to a lower level (remember Max Planck?). Absorption spectra are caused by electrons absorbing energy to "jump" "up".

7. The blue beads fluoresce, converting UV to visible light at wavelengths which disguise natural "yellowing". Try the school UV source on a sample.

8. Absorbs UV at the surface - no damage further down.

9. See above, written sideways.

See also exercises 70, 82, 145 and 146.

SOURCE: Life Science Library - "Energy". ★★★

71

INFRA-RED

Soft as the touch of visible light usually is, it is one of the two forms of radiant energy that human senses can detect directly. The other form is infra-red heat energy.

The fact that infra-red energy is a form of invisible light was discovered by Sir William Herschel at the turn of the nineteenth century. Herschel, a pioneer of stellar astronomy, began examining light from sunspots through differently coloured filters. In 1800, he discovered that some produced the effect of heat, others did not. He sought the cause of this difference.

Using a prism he spread a beam of sunlight into the continuous band of colour known as the spectrum. He observed that yellow was the brightest light and that red gave off the greatest heat. To his surprise, however, the jightest temperature of all occurred in invisible radiation just below the visible red light. This infra-red light is a prominent part of the radiation which we now recognise as being thrown off by any hot object.

WHOOPS! this should be highest!

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of the following words as used in this passage?
radiant (line 2), stellar (line 6), prism (line 10), spread (line 10).

2. What direct observation caused the discovery of infra-red radiation?

3. What was Herschel trying to do when he found infra-red radiation?

4. Draw a diagram which shows how a prism would spread a beam of sunlight. What is this spreading (line 10) called in physics?

RESEARCH QUESTIONS

5. What is the literal meaning of infra-red?
What are some of the uses of infra-red radiation?
Is it dangerous?

6. Heat energy can be transferred in several ways. Thrown-off (line [illegible]) roughly describes one of these. Describe each way in which heat can be transferred.

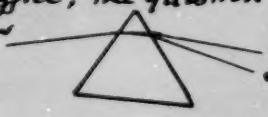
7. Herschel was a stellar astronomer (line 6). No, he doesn't tell people about astronomy.
What does a stellar astronomer do?

Latin stella = star

8. How many Herschels were involved in astronomy?
Who were they, and what did they discover?

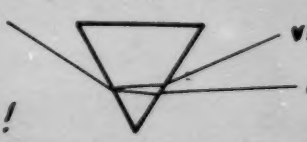
8. Sir William, his sister Caroline, and his son Sir John. Caroline, amongst other things, discovered eight comets.

RANDOM NOTE. Seated one day in the office, the question arose: why infra (below) red? Most textbooks show



So infra-red would be above red!

Our resident trivid* says Newton used a beam of sunlight coming through the roof - so there you are:



*It's his own word: we think he wants us to ask him what it means. But we're not so naive!

See also exercises 45 and 46.

★★★

SOURCE: Progress Column in the Sun-Herald, April 22, 1979, p.162.

We presume that this was the grandfather (also a physicist, as was the father) of the Becquerel who discovered radioactivity. We contacted the author, but he could not help us - he no longer had the research notes. Asimov says that the grandfather "helped found electrochemistry".

ELECTRICITY FROM THE SUN

72a

The recent announcement of a grant to researchers at the University of N.S.W. for the development of a new type of solar cell is noteworthy. The solar cell will undoubtedly play an important part in the future energy situation. It is already playing a vital role in space technology. If solar cells or batteries are already employed for space technology it might be wondered why intensive research is still necessary. It is because of the cost of production and the efficiency of operation. The principle of how the solar cell works is not new. As far back as 1839, Becquerel discovered that the electromotive force of a certain type of voltaic cell changed if one electrode was strongly illuminated.

FROM RADIOS TO BUSES

The solar cell is a unit to convert radiant energy directly into electricity. That is why it is so suitable as a power supply for space craft as the cells can be continually activated by interrupted exposure to sunlight, but such cells can be used to power anything from satellites to transistor radios and even road vehicles.

It should be remembered that the activating factor is light, not heat - although heat can also be utilised if required by means of a thermo-couple which works on the principle that when two different metals in contact are heated, an electric current flows through them. *

A typical modern solar cell consists of a wafer-thin piece of silicon, smaller than a razor blade. There are actually two layers of silicon each with a different electrical property so that when sunlight strikes the cell, electrons move from the first or positive layer to the second or negative layer thus producing a flow of current.

RESEARCH

One of the main technological objectives of the late '70s has been efficient direct conversion of solar energy to electricity. Crystalline silicon solar cells can perform the task with an efficiency of 22% but they are too expensive for large scale production. Experimenters at the University of Dundee, Scotland, prepared special thin films of amorphous silicon, th electrical conductivity of which could be varied by a factor of 600 to 000 by the addition of small amounts of phosphorus and boron.

Australian research is directed at eliminating the need to introduce impurities. This is achieved by means of a very thin insulating layer which is "grown" on top of the silicon.

The overall result is a considerably increased energy conversion efficiency. But, the method also seems to hold the possibility of using low grade silicon - thereby putting large scale commercial production within practical reach.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of these words as they are used in the passage?

   vital (line 4), intensive (line 6), efficiency (line 7), electrode (line 9), illuminated (line 10), activated (line 14), amorphous (line 31).

2. The following phrases are used in the article. What do they mean?

   space technology (line 4), electromotive force (line 9) radiant energy (line 12), solar energy (line 28) electrical conductivity (line 32)

3. (a) What is a thermo-couple (line 18)?
   (b) How does it work?
   (c) How could you make a simple thermo-couple?

* The thermo-electric effect was discovered by Seebeck in 1826. In his list, current flows across the heated junction from the first-named to the second: Bi, Pt, Cu, Pb, Sn, Ag, Zn, Fe, Sb, Te. Thermopiles commonly use bismuth and antimony, with bismuth positive.

NB: a microammeter will typically show about 20 microamps from one twisted-wire thermocouple. Spitting on the junction gives about 40 microamps!

4. What energy conversion is taking place in a solar cell?
Light → electricity

5. What advantage is there in having solar cells operating in space rather than in the earth's atmosphere?
More radiation

6. What is meant by the statement that crystalline silicon solar cells have "an efficiency of 22%" (line 29)?
Convert 22% of incident radiation

7. What are the experiments at the University of Dundee aiming to do?
Produce cells which are both cheap and efficient.

8. What are Australian researchers doing in this field? What have they found out so far?
See para 7.

RESEARCH QUESTIONS

9.* What sort of substances are silicon, phosphorus and boron?

10.* To what use could solar cells be put to on earth? Are they used very much at present?

11. Draw a simple labelled diagram of a cross-section of a solar cell.
On your diagram draw arrows to indicate the direction of the electron flow when sunlight falls on the cell.

* Tell your students how much depth you want:

one word ?
one sentence ?
one paragraph ?
one thesis ?

See also exercise 69.

★★★

CHEMICAL ENERGY 73

Of all the forms of energy, none is so useful and vital to the life of man as chemical energy. Much of this importance stems from its tremendous versatility.

Sometimes, as in ordinary fuels such as coal or wood, the chemical energy is so readily given up that a lighted match is all that is needed to release it. But there is also latent chemical energy in a diamond which does not burn until it is heated to 650°C.

Chemical energy can be controlled so easily that we can use it to toast meringues. Yet it can be explosively uncontrollable as in a bomb. The pages of a book slowly release chemical energy as they combine with oxygen in the air. The pages slowly yellow as a result of this slow "burning". In contrast, the five strands of metal in a photographic flash bulb burn almost instantaneously in a blinding flash of light.

Chemical energy is released when the chemical bonds that hold matter together are rearranged. Atoms are tightly bonded together to produce molecules. Molecules are bound up into larger pieces of matter that are big enough to see and touch. An atom of oxygen, for example, will join in a firm partnership with two hydrogen atoms to form a molecule of water. And many molecules of water will incorporate to form raindrops, oceans and icebergs.

Every bonding between atom and atom, molecule and molecule is a potential source of energy.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? versatility (line 3), matter (line 16), latent (line 6), incorporate (line 19), potential (line 22).
2. What is the source of chemical energy?

Lines 17 → 18

3. What is the structure of a water molecule?
4. What is the difference between an atom and a molecule (lines 15 and 16 respectively). Give examples to illustrate your answer.

END OF PART 1.

RESEARCH QUESTIONS

5. What is a chemical bond - describe briefly the various types of chemical bonds, using examples of compounds which contain each.

Try these two terms for starters

6. The passage says "chemical energy is created when the bonds that cement matter together are broken". Strictly speaking this statement is incorrect. Why? What does it really mean to say?
   Can you see two mistakes in this sentence?
7. Give a brief description of 3 direct applications of man's use of chemical energy.

Oxy-welding, gas-cooking, explosives.

Internal combustion is NOT direct.

See also exercise 49.

★★★

ANTOINE LAURENT LAVOISIER 74

Lavoisier's best known contribution to science is his demolition of the phlogiston theory. Phlogiston was thought to be an invisible substance present in all combustible materials and in metals. It was an all-purpose ingredient which was used to explain all sorts of chemical reactions.

The reason some substances crumbled to ash when burned was thought to be that phlogiston departed from them. The reason a *calx* (metallic oxide) turned back into metal when it is heated on a carbon block, was because phlogiston joined it from the carbon. Depending on the particular chemical reaction phlogiston could have weight, be weightless or even have negative weight. It was this aspect of the phlogiston theory which made some scientists uncertain and which eventually led to its downfall.

Using a very accurate balance Lavoisier performed a classic series of experiments. In one, he placed some tin in a flask, sealed it, weighed it, and heated it, until no more powdery calx "was formed". He reweighed the flask and found no weight change. Then he broke the seal allowing air to rush in. He reweighed the flask and noticed an increase.

Lavoisier concluded that the increase was due to the weight of air rushing in when the flask was unsealed. This air had replaced original air which had been used up in forming the calx. Just what had been removed from the air in the calx forming process Lavoisier didn't know. Later, however, an experiment performed by Joseph Priestley gave him a clue.

Instead of forming a calx, Priestley unformed one. He heated red mercuric oxide. In the process he liberated a gas, which, as a confirmed phlogistonist, he labelled "dephlogisticated air". Lavoisier, collecting some of this "air" in a new experiment, found it to be what he sought. It was the one responsible for both combustion and for forming calx. He named it oxygen.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? combustible (line 3), balance (line 12), classic series (line 12), unformed (line 22), liberated (line 23).

2. Explain how Lavoisier's observations falsified the phlogiston theory.

3. What was meant by "dephlogisticated air"? (line 24)

4. One part of the phlogiston theory allowed phlogiston to have weight, be weightless or even have negative weight (line 9). Some scientists would be unwilling to accept this part of the theory. Why?

5. Use the phlogiston theory as the "phlogistonists" would have used it to explain these observations.
(a) When heated in air, magnesium burns with a brilliant flame forming a powdery calx which is heavier than the original magnesium.
(b) The calx formed from burning a log of wood has only a fraction of the original weight of the log.

And releasing lots of UV! Beware! ←

RESEARCH QUESTIONS

6. Lavoisier is also credited with laying down the basic standard by which a substance could be tested to be an element or not. What is it?

7. How did Lavoisier die? What did Coffinhal have to say about Lavoisier's death?

WHOOPS!

6. Substances which have not (yet) been broken down into still simpler substances. See Dobbs' The Age of the Molecule, Harper and Row, 1976, for a list of the elements of Lavoisier (on p. 9). Silica, alumina and magnesia were on the list.

7. By the guillotine. "La République n'a pas besoin de Savants" — the republic has no need of scientists.

See also exercises 49, 67, 76 and 83

★★

GASES 75

Although more is known now about gases than either solids or liquids, gases were the last to be identified as a distinct state of matter. Until the seventeenth century, with its proliferation of scientific techniques and tools, gases remained hard to capture and analyse. They could not, like solids, be broken, bent or powdered. They could not, like liquids, be poured, soaked up, frozen or boiled.

The Greeks were the first to recognise that air had substance. In the fifth century B.C., the philosopher Empedocles noticed that a container, inverted in water did not completely fill with water. Empedocles concluded that air in the vessel resisted the influx of the water.

Satisfied that air had substance, the Greeks though that it also had weight, but were unable to confirm this experimentally. One hundred years later, Aristotle decided that an empty space could not exist in nature. The convenient catch phrase "nature abhors a vacuum" sufficed for the next 2 000 years to explain the effects of weightiness of air in early siphons, bellows and pumps. In the 17th Century, Galileo provided the answer in a simple experiment which showed that air has weight. On his scales he balanced a sealed vessel containing nothing but air at normal atmospheric pressure against a heap of sand. Then he pumped more air into the vessel, resealed it and put it back on the scales. He found that it outweighed the sand. Galileo reasoned that the added weight could only be due to the increased amount of air inside the vessel.

Empedocles was the originator of the "four-element" theory of matter. In this, he combined the views of others – see below.

WHOOPS !

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article? distinct (line 2), matter (line 2), proliferation (line 3), analyse (line 4), inverted (line 9), resisted (line 10), influx (line 10).

2. Why were gases the last to be identified as a state of matter? Line 4

3. What is meant by the phrase "nature abhors a vacuum" (line 14)?

4. From the article, work out in which century Aristotle lived? 4th century BC

5. Why was it not until Galileo's time that an experiment to show that air had weight could be devised?

6. List at least 3 differences between solids, liquids and gases mentioned in the article. Lines 5 and 6

7. What steps did Galileo take in his experiment to show that air has weight. Line 16 + following or Dover edition of "Discourse" p. 79 or Hogben 94-95

S. Pumps had to be invented which could pump air. BUT, according to Galileo, Aristotle said an inflated leather bag weighs more than an empty one. "Discourse on Two New Sciences", First Day (121) p.77 of the Dover edition.

RESEARCH QUESTIONS

8. What was a philosopher (line 8) in the 5th Century B.C.? Is a modern day philosopher the same sort of person? Name 5 other philosophers from the early days of science. Why were these people NOT called scientists? * See Bertrand Russell "History of Western Philosophy"

9. Explain how either a siphon bellows or a pump could give an effect of weightiness of air (line 15). Use a diagram to show how the one you choose works.

10. What is normal atmospheric pressure (line 18)? How is this measured? Draw a diagram to show how this instrument works. Specify Torricellian or aneroid.

11. Atmospheric pressure as expressed as 760 mm of mercury or 101.3 kPa. Show how these are identical measurements.

$P = h\rho g$. Remember? ($\rho = 13.6\ g/mL$)

See also Hogben "Columbus, the Cannon Ball and the Common Pump" Heinemann 1974.

* You will probably find Pythagoras, Socrates, Plato, Aristotle, Democritus, Lucretius, for starters. Also present may be those whom Empedocles combined: Thales (water), Anaximenes (air), Heraclitus (fire), and Xenophanes (earth).

See also exercises 49, 67, 75 and 83

★★

SIZE OF GAS MOLECULES 76

Particles of matter are very small. They are also very close together. Or are they? Let us look at the molecules of a gas.

The radius of a small gas molecule is about 30 nm. One nm (nanometre) is 10^{-9} metres. The average distance between molecules is about 300 nm. This means that the distance between molecules is ten times their radius.

If one of these molecules was the same size as earth, the next molecule, also the same size as earth, would be 128 000 km away. This is ~~still on~~ the way to the moon.

one third of

In fact, if we look at this in terms of the space occupied by molecules - only $\frac{1}{1\,000}$ of the available space is occupied by matter. This is 0.1%. In other words, 99.9% of the air you breathe is empty space! The size of these molecules can be emphasised perhaps if we know this: there are 26 868 300 000 000 000 000 of them in *one cubic centimetre* of space! And then, they only take up 0.1% of that space!

Why do the gas molecules stay so far apart? Why don't they gravitate together? The answer is that they possess energy which takes the form of rapid motion. This motion jostles the molecules apart.

WHOOPS! Our source was wrong - the print master will be altered.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article? particles (line 1), matter (line 1), radius (line 3), average (line 4), gravitate (line 17), jostles (line 18).

2. How many "earth molecules" would fit between the earth and the moon? Draw a simple diagram to show this.

3. What is the distance between the earth and the moon? ≈ 400 000 km

4. How far apart, in centimetres, are the molecules of a gas? 3×10^{-9} cm
(we should, strictly, ask for millimetres)

5. What is the diameter of the earth?
12 714 km (equatorial) ≈ 12 756 km (polar)

6. How many air particles are there in one cubic centimetre of air? Express this number in scientific notation. Is cubic centimetre an acceptable unit for scientific use? See line 14
No; use mL instead.

7. You have a 100 mL container of air. How much of this is empty space? 99.9 % or 99.9 mL

RESEARCH QUESTIONS

8. (a) Assume it was possible to have one cubic centimetre *completely full* of air molecules. How many air molecules would this cubic centimetre contain?
The number on line 14 with three more zeros.
(b) From your answer to (a) calculate the volume occupied by one air molecule. $\frac{1}{2}.7 \times 10^{-22}$ mL

9. Who first worked out how many molecules occupy a given space? Find out more about this scientist. What other work did he do? Avogadro

10. What did the following scientists contribute to the study of the sizes of particles?
(a) Amedeo Avogadro
(b) James Clerk Maxwell
(c) Ludwig Boltzmann

These are the correct spellings!

This is a very hard question: are your students ready for it? Are you?

See also exercises 67, 78, 79, 80.

SOURCE: New Horizon Library - Atoms and Energy ★

77a

WHAT ARE ATOMS MADE OF?

If we could look inside the atom, we would spot a tiny, solid body lying at its centre. This body - the *nucleus* - is only one ten-thousandth the size of the atom. Between it and the electrons at the outside is empty space. Although the nucleus is so small, it is several thousand times heavier than the electrons that move around it.

The electric charge on each electron is called a *negative* charge. The nucleus has several *positive* electric charges. In fact, the number of negative charges on the electrons is normally equal to the number of positive charges on the nucleus. The positive and negative charges cancel each other out, so the atom as a whole normally has no overall electric charge. But when an electric current flows, electrons move among atoms, producing a movement of electric charge. A flash of lightning happens when great differences in electric charge build up between atoms in the air.

It is a basic law of electricity that like charges repel each other and unlike charges attract. This explains why atoms can make up solid objects, even though they consist mainly of clouds of electricity. If two atoms closely approach each other, the electrons at the outside of each atom repel each other because they have the same negative charge. The closer they approach the more strongly they push each other apart. It is impossible for one atom to move inside another. Forces other than electric forces keep the atoms together in the arrangements that make up solids and liquids.

The nucleus of an atom is in fact not completely solid. It is made up of smaller particles grouped tightly together. One of these particles is called the *proton*. It has one positive electric charge, and is nearly 2 000 times heavier than an electron. The total number of protons in the nucleus normally equals the number of electrons. This is why the positive and negative charges in an atom are usually equal in number. The simplest atoms have a nucleus of one proton surrounded by one orbiting electron. These atoms are hydrogen atoms.

All the other elements apart from hydrogen contain another kind of particle in the nucleus of their atoms. This particle is called the *neutron*. It is almost exactly like the proton, except that it has no electric charge. An atom of carbon, for example, has six electrons and therefore its nucleus contains six protons. But the nucleus also has six neutrons.

These simplifications are justified by the needs of "one-star" readers.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article?

   cancel (line 9), basic (line 15), law (line 15), arrangements (line 22).

2. What causes two atoms to repel each other?

3. Draw a diagram showing the structure of a carbon atom. Label each part.

4. If the nucleus of an atom was one millimetre across, how far away from it in metres would the last electrons be, according to the information given in the passage.

5. Why does an atom normally have *no* overall electric charge? Lines 27 • 28

6. A sodium atom has 12 neutrons and 11 electrons. How many protons does it have? 11.

We wonder if these "models" might not be counter-productive. See our comments on ex. 78, question 9.

Taking "one ten-thousandth" (line 2) as a linear measure, the answer would be 5 metres (radius)

Do your students know how to draw up a table? Try them - you may be worried by what you find.

77b

7. Copy and complete the following table from the information found in this article?

Name of Particle	*Charge on Particle*	*Where in atom it is found*	*Relative mass of Particle (Proton = 2 000)*

RESEARCH QUESTIONS

8. What is an electric current (line 11)? How is it formed? Why do some substances conduct an electric current, while others do not?

9. Find out the name of the scientist who discovered the basic law of electricity. (paragraph 3)

Charles Augustin de Coulomb. Cavendish actually did it first, but he did not publish his results (he was a bit funny that way). Priestley deduced the result, but did not test it out.

If your students name Ampère, Oersted, Ohm etc., they missed the hint in brackets.

See also exercises 64, 67, 77, 79 and 80.

Source: New Horizons Library - Atoms and Energy.

★★

78a

WHAT ARE ATOMS LIKE?

It is difficult to grasp the idea of something as small as an atom. If we say that 250 000 million them go to make up the full stop at the end of this sentence it really means very little to us. Perhaps the best way is to imagine an atom enlarged to the size of something you know, and then to consider how big other familiar objects would be in comparison. For example, if the smallest atom were the size of the nail on your little finger, then your hand would be as big as the world! That gives you a rough idea of the size of the smallest atom. It is in fact a hundred-millionth of a centimetre across. Even the largest atoms are not much larger than this.

The Arrangement of Atoms. We do not really know what an atom looks like. It is possible to take pictures of large atoms through special microscopes, but the pictures show only white blobs. It is not, in fact, important what an atom looks like. The atoms in an object would not look like the small pieces of the object. A hydrogen atom from a sample of red paint would appear just the same as one from colourless water. The appearance of anything depends on the way the atoms are arranged, rather than the actual appearance of the atoms themselves.

The arrangement of atoms or molecules in anything also determines whether it is a gas like the air, liquid like water, or solid like the chair on which you are sitting. There are forces between the atoms or molecules that pull them together. In a solid, the forces are strong and the atoms or molecules pack tightly together. It is difficult for the atoms or molecules of anything else to enter the tight arrangement in a solid, so solids are strong enough to support themselves and often other objects too. In a liquid, the forces are not so strong and the atoms or molecules have a loose arrangement. The liquid can flow to take up any shape and other objects can move through it. In gases, the forces are very weak and the gas atoms or molecules are not arranged in any way. They can move apart until the gas fills its container.

Heat Makes Atoms Vibrate. We can change a solid into a liquid and a liquid into a gas by heating it. The solid melts and the liquid boils. This happens because heat reduces the forces linking the atoms or molecules. The atoms or molecules are always vibrating, even in the tight arrangement of a solid. The hotter they get, the more they vibrate. If a solid is heated enough, the atoms or molecules vibrate so much that the arrangement becomes loose and the solid melts to liquid. If the liquid is heated sufficiently, the atoms or molecules move more and more and break away from the arrangement. The liquid boils and becomes a gas. In a gas, the atoms or molecules are flying about at random in all directions.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article?

   grasp (line 1), atom (line 1), microscopes (line 12), molecules (line 19), determines (line 19), random (line 40).

2. Using the information in this article copy and complete the following table:

Check your students' results on this one!

State of matter	Relative strength of forces holding molecules together	Arrangement of molecules in states of matter

78b

3. Briefly describe, in your own words, what happens to the atoms of a solid as it is changed into a liquid and then into a gas. Para. 4

4. In paragraph two we are told that "we do not really know what an atom looks like". Why not? Too small

5. What is it that gives colour to substances? Para. 2 will do until we get to senior Chemistry

6. What would we have to do to a gas in order to change it into a liquid? Cool it - we will ignore pressure in this context.

7. (a) Express a hundred-millionth of a centimetre (lines 8 and 9) in metres
   (i) as a decimal. $0.000\,000\,0001$ m
   (ii) in scientific notation. 10^{-10} m

   (b) How many atoms lying side by side would be needed to form a row 1 metre long? 10^{10}

RESEARCH QUESTIONS

8. (a) What is (i) the smallest atom known? Hydrogen
   (ii) the biggest atom known? Francium (unstable) or Caesium (stable)

   (b) Exactly how big, in metres, is each of these.

   (c) Arrange the atoms of these elements in order of smallest to largest.
   sodium, potassium, lithium, fluorine, chlorine, bromine, iodine, lead, copper, iron.

9. Draw a labelled diagram of an atom showing all its parts. How does a hydrogen atom differ from an oxygen atom?

10. Why would the atoms in an object not look like small pieces of the object? (see paragraph 2). Give examples to illustrate your answer.

8. See the introduction to "Properties of the elements" in "SI Chem Data" for some answers. We quote from Stranks et al. (1965) which gives figures generally in agreement with "SI Chem Data". All measurements are in pm. Na: 186, K: 231, Li: 152, F: 64, Cl: 99, Br: 114, I: 133, Pb: 175, Cu: 128, Fe: 126, so order is
F, Cl, Br, Fe, Cu, I, Li, Pb, Na, K.

9. Their hydrogens will (presumably) have no neutrons. We are led to wonder: how many students leave school without going beyond the naïve "solar-system-round-a-plum-pudding" model? Does it matter? We think so!

10. A model answer would point out that properties of a substance depend on the size, shape, charge, preferred charge, distribution of charge and type of bonding in the particles. Since some of these are molecular properties, there is your answer.

See also exercises 67, 77, 78, 80, 83.

SOURCE: New Horizon Library : Atoms and Energy ★★★

79a

HOW DO ATOMS JOIN TOGETHER?

The main substances we use that are elements are the oxygen we breathe in the air; some metals, especially aluminium; and carbon in the form of fuels such as coke. Almost all the substances we use in our everyday lives - such as water, salt, wood, cloth, food and medicines - are made of compounds rather than elements. To make compounds, atoms of different elements must join together. This can happen in two ways.

Atoms can gain or lose electrons to form ions. If an atom gains an electron, it also gains the negative electric charge of the electron. It becomes a negative ion. If an atom loses an electron, it loses the negative charge and becomes a positive ion. Because unlike electric charges attract each other, a negative ion and positive ion will be pulled together, rather like the way a magnet attracts iron. A bond called an *ionic bond* forms between the two atoms. Many atoms can join together in this way to make up a tight arrangement of atoms.

The other way in which atoms can join together is by sharing electrons rather than by exchanging them. When an ionic bond forms, one atom gives one or more electrons to another atom. The electrons move from one atom to the other. But in many compounds, electrons are given by both the atoms that join. The electrons move around both atoms, forming a bond called a *covalent bond*. In some kinds of covalent bonds, the electrons come from one of the joining atoms instead of from both.

When ionic bonds form, the electrical attraction can bring any number of atoms together in a great arrangement of atoms. The arrangement has no set size, and more atoms can simply join on to it if necessary. But when covalent bonds form between atoms, a definite group of atoms join together. If there are more atoms around, they form separate identical groups. These groups are called *molecules*. We therefore find molecules in covalent compounds, but not in ionic compounds.

The way in which atoms join to make a compound may give the compound a certain shape. Salt, for example, is always found as cube-shaped crystals. The salt crystals in a packet of salt are very small, but it is possible to grow large cube-shaped crystals of salt. The crystals have a cubic shape because the atoms in them are joined togher in a cube-shaped network.

But we cannot always grow crystals of substances to find out how the atoms are arranged inside them. Instead scientists pass a beam of X-rays through a substance. The beam is split up by the atoms in the crystal and produces a pattern on a photographic film. From the pattern, scientists can tell how the atoms are arranged in the crystal. In this way, they found that the huge molecule of DNA consists of two long chains of atoms shaped like two spiral staircases winding around each other. It is these complicated DNA molecules that pass on all heredity information from one generation of living cells to the next.

we would probably have done well to amend this to hereditary.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR ONW PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? elements (line 1), compounds (line 5), atoms (line 7), bond (line 19), molecules (line 27).

2. What is an ion (line 7)? Explain how the different types of ions form. Re-state lines 7-10.

3. What are the differences between ionic bonds (line 13) and covalent bonds (lines 19 and 20)?
You could summarise your answer in the form of a table.
Is this suitable for your class?

4. Why do we find molecules in covalent substances, but not in ionic substances? Line 25

5. What gives crystals their characteristic shapes? Line 29.

RESEARCH QUESTIONS 79b

6. Draw up a table which shows ten different compounds, and the following information: Formula of the compound, elements in the compound, are the elements joined by ionic or covalent bonds, is the compound ionic or covalent?

7. The article states that ions are held together because unlike electric charges attract each other (lines 10 and 11). Using the compound sodium chloride as an example, show how the ions form and why they attract each other.

8. Write a short explanation of how X-rays are used to determine the structure of a crystal. Are there any other ways of finding out this information?

9. (a) What do the letters DNA stand for?

(b) Who discovered the structure of DNA? When?

(c) Why was this discovery a breakthrough in biological science?

6. This question could be further developed by requiring that each compound contain one element not found in any of the others.

7. Sodium is 2, 8, 1 and chlorine is 2, 8, 7. Schools were issued with a nice model in the late 'sixties.

8. Bernie Shephard has shown STANSW members how to make diffraction patterns with all sorts of unlikely things: panty hose, negatives of pictures of typed symbols, and so on. We saw it by going to conferences, but can't find it in SEN. Maybe this will give you some ideas.

9. Deoxyribonucleic acid. "Desoxy...." and "Deoxyribose...." are no longer used.

(b) Crick, Watson, Wilkins, probably also Rosalind Franklin. We would add von Laue, the Braggs, Kendrew, Perutz, Erwin Chargaff (especially) and others. How about you?

(c) This needs discussion in class: we gain insight into genetics and evolution and (be careful!) genetic engineering. Once we understand the genetic code, Biology ceases to be so dismissable as it was to Rutherford:

"There are two kinds of Science: Physics and stamp-collecting."

Biology is now a more sincere form of philately.

See also exercises 67, 77, 78, 79.

SOURCE: New Horizon Library : Atoms and Energy ★★

KINDS OF ATOMS 80a

There are only about a hundred different kinds of atoms, yet they combine together to make up everything in the universe.

Atoms are made up of nuclei containing protons and neutrons, around which electrons move. One atom is therefore going to be different from another if it contains different numbers of these particles. Substances that contain only one kind of atom are known as *elements*. Hydrogen, oxygen, carbon and chlorine are elements. So are metals such as mercury, copper, sodium, gold, silver and uranium. An atom of one element is different from an atom of another element because it has a different number of protons in its nucleus. A hydrogen atom has one proton, a carbon atom six and an oxygen atom eight, for example. Altogether 105 different elements are known. But some of these are not found in nature because they change into atoms of other elements very quickly. They can be made artificially, but have a very short life. Less than 100 elements are found in nature, and the whole universe is made up of them.

But the universe obviously contains many thousands of different substances, and not only a hundred or so elements. This is because most substances consist of combinations of two or more elements. They are called *compounds*. As there are thousands of possible combinations of elements, there are thousands of different compounds. The electrons in the atoms are involved when atoms come together to make compounds. Atoms may gain or lose electrons. This does not make any difference to the identity of the element. It is the number of protons in the nucleus that matters, and this number is called the *atomic number*. Each element has its own atomic number. Hydrogen is 1, carbon 6, oxygen 8, and so on. If an atom were to lose or gain protons, it would become an atom of another element because its atomic number would change.

What happens if the number of neutrons in the nucleus changes. In fact, very little happens. The atom is exactly the same except that it is a little lighter or heavier. An element looks and behaves identically however many neutrons its nuclei contain, as long as its behaviour does not involve the nuclei. Making compounds does not involve the nucleus, nor does the appearance of an element. In fact, many elements that occur in nature are mixtures of atoms containing different numbers of neutrons. Chlorine, for example, is a mixture of atoms containing 18 or 20 neutrons per nucleus. The chlorine nucleus has 17 protons, so that nuclei of chlorine contain 35 or 37 particles.

Those funny plurals again!

Atoms of an element that contain different numbers of neutrons are called *isotopes*. Chlorine is made up of two isotopes. They are called chlorine-35 and chlorine-37.

Some elements occur in nature as only one isotope. Natural aluminium, for exaple, is made up of only aluminium-27. Other elements are mixtures of two or more isotopes. Tin, for example, occurs as a mixture of ten isotopes. But many more isotopes of all the elements can be made artificially. These isotopes do not occur in nature because they always break down into atoms of other elements.

whoops!

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article? elements (line 6), artificially (line 13), compounds (line 19), nucleus (line 23), mixture (line 34), isotope (line 39).
2. At the end of paragraph one, it is stated that the universe is made up of less than 100 elements. What assumption have scientists made which allows them to say this?
3. What causes one element to be different from another? Why is sodium different from magnesium?

Question 2: We assume that our corner of the Universe is typical, and that trans-Uranics have not formed in the "Island of stability" - remember the fuss about haloes in mica a few years ago?

3. See the note for question 10 in exercise 78.

80b

4. (a) If a uranium atom lost a neutron, it would still be a uranium atom. However if it lost a proton, it would no longer be a uranium atom. Explain why.

(b) What would a uranium atom be if it lost a proton?

(c) What would a uranium atom be if it lost
(i) an electron, (ii) two electrons? An ion, at the simple level. Anyone for β decay?

5. What is the atomic number of chlorine? What evidence in the article enables you to answer this question? 17 - see line 36

6. How many (i) protons and 1(a) 17, 1(b) 17 ii(a) 18 ii(b) 20
(ii) neutrons in an atom of a) chlorine-35
b) chlorine-37?

7. In each of the following cases state whether or not a new element would be formed? Explain your answers.
(i) A hydrogen atom loses an electron. NO
(ii) A sulphur atom gains two electrons. NO
(iii) A carbon atom gains two neutrons. NO
(iv) A uranium atom loses 2 protons. YES

8. (a) What is meant by chlorine-35 (line 40), chlorine-37 (line 40) and aluminium-27 (line 42).

(b) What do the numbers mean, and how are they obtained?
Stress approximate mass!

RESEARCH QUESTIONS

9. Sodium-23 has an atomic number of 11. How many protons and neutrons are contained in the nucleus of an atom of sodium-23?

10. When was this article most probably written?
(a) 1960 (b) 1965 (c) 1970 (d) 1975 ← possible!
Explain your answer including evidence from the article.
See line 11 - Hahnium (No 105) discovered 1970.

11. (a) What is atomic mass?

(b) Divide all the elements mentioned in the passage into metals and non-metals. Alongside each write its atomic number, how many protons, neutrons and electrons an atom of each element has and the atomic mass of each.

12. Name 5 compounds and the elements which combine together to form them.

13. Name 5 other elements which have isotopes. List the isotopes along with their atomic numbers, and atomic weights.
See SI Chem Data, or any senior chem. text.

14. Protium, Deuterium and Tritium are the only isotopes with their own names.
(i) of which element are they isotopes? Hydrogen
(ii) why were they so named? mass 1, 2, 3
(iii) what is the common name for Deuterium oxide. Heavy water
(iv) for what reason is Deuterium oxide used in the nuclear industry? As a moderator in reactors (see passage 81)

Heavy water: "water containing a substantial proportion of deuterium atoms (D_2O or HDO)."
- Chambers Dictionary of Science & Technology (1974)

This is a valuable resource

See also exercises 77, 80, 134, 135, 136, 137, 138, 139

Informed debate feeds on information.....

SOURCE: New Horizon Library: "Atoms and Energy" ★★★

CONTROLLING THE ATOM 81

An atom bomb explodes because a chain reaction multiplies and gets out of hand. Each fission of an atom produces neutrons that cause two or three more fissions, which produce more neutrons that cause even more fissions and so on, all in a fraction of a second. But if the chain reaction is slowed so that only one neutron from a fission causes another fission, then the reaction proceeds steadily and does not multiply. This happens in a nuclear reactor. It is made so that a runaway chain reaction and a nuclear explosion are impossible.

In natural uranium, only one in every 140 atoms is uranium-235. The other atoms are uranium-238, which does not produce fission when struck by neutrons. A chain reaction does not occur in natural uranium because there are not enough uranium-235 atoms to keep it going. A fission of a uranium-235 atom may occur, but the neutrons produced will most probably be absorbed by the uranium-238 atoms. Also, the fission produces fast-moving neutrons, which tend to bounce off uranium-235 atoms. Further fission is much more likely to happen if the neutrons move more slowly. A nuclear reactor can therefore work if the natural uranium is treated to increase the amount of uranium-235, and if the neutrons produced are slowed down.

The fuel for reactors therefore usually consists of *enriched* uranium or uranium compounds, which contain a higher proportion of uranium-235. The fuel is placed in long tubes, which fit into the *core* - the centre of the reactor. To help make the chain reaction go, a *moderator* is placed around the fuel to slow the neutrons produced by fission of the fuel. The moderator is usually graphite or water. In case the chain reaction starts to go too quickly, *control rods* are also inserted into the core. They are made of metals such as cadmium or boron that absorb neutrons and can be moved in or out of the core.

As the chain reaction proceeds steadily in the fuel, heat is produced. If the core gets too hot, the control rods are pushed in to take up some neutrons and slow the chain reaction. The reactor cannot explode, but it can get dangerously hot. In this case, the control rods can be pushed right into the core to stop the chain reaction. The core is surrounded by a thick layer of concrete to stop radiation and neutrons from escaping and harming people. This is called a *biological shield*.

A cooling liquid or gas passes through tubes in the core to take up the heat. This heat can then be used to produce steam which, in turn can be used as a source of power.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   fission (line 2), neutrons (line 3), natural (line 9), enriched (line 19), radiation (line 33).
2. How is a chain reaction (line 1) produced?
3. Explain how a chain reaction is prevented from getting out of control in a nuclear reactor.
4. Why doesn't a chain reaction occur naturally in uranium?
5. What are the conditions required before a chain reaction will occur? See answer to Q. 2.
6. Explain the function of the following parts of a nuclear reactor.
   moderator (line 22), control rods (line 25), biological shield (line 34), cooling liquid (line 35).

2. Each released neutron causes (on average) the formation of >1 new neutrons.
3. Excess neutrons are absorbed.
4. Lack of sufficient U-235 *

* The standard level of U-235 is 0·72%, but deposits in Gabon run as low as 0·444%, and as high as 0·74%. The isotopes of cerium, europium, neodymium and samarium show compositions typical of man-made reactors (but not natural!).
Dr. Francis Perrin suggests that this indicates an unexplained (natural) enrichment, leading to a natural chain reaction, and consequent depletion of U-235. He thinks this happened 1700 million years ago.
See New Scientist 9-11-72, pp 342-3 for more details.

See also exercises 70, 71.

★★★

THE DISCOVERY OF X-RAYS 82

In 1895 X-rays were discovered by William Konrad RÖntgen, a physics professor at the University of Wurzburg in Germany. He was working with a cathode tube in which a current of electricity was passed through a vacuum from one terminal inside the tube to the other. Because such a tube glows slightly when the current flows, RÖntgen had darkened the room to see the glow better. Suddenly he noted that a piece of nearby glass covered with a barium salt also glowed whenever the tube was operating. This occurred even though the glass was screened from the apparatus by a piece of black paper. He put a book in front of the tube and the glass still glowed. Then he substituted a piece of wood, and finally a piece of aluminium. The rays penetrated everything, including his hand. Furthermore, when he held his hand between the cathode tube and a photographic plate, the skeletal image was left on the plate. RÖntgen's discovery created as much flurry in the press of his day as did the moon landing in modern times. More than 1 000 scientific articles were published on the new X-rays in just the first year of its discovery.

barium platinocyanide

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?

   vacuum (line 3), terminal (line 4), apparatus (line 8), image (line 13).

2. How were X-rays discovered? How much detail do you want?

3. Name 4 substances which are able to be penetrated by X-rays.
   Lines 9, 10, 11

RESEARCH QUESTIONS

4. What is a barium salt (line 7)? What is a salt in chemistry? Name and give the chemical formulae for 3 barium salts.

5. What is a cathode ray tube? Draw a labelled diagram of a cathode ray tube. List 5 uses man has for cathode ray tubes.
   CRO, TV, radio valves as amps & rectifiers....

6. What was RÖntgen trying to do when he accidentally discovered X-rays? Repeat the experiments of Lenard & Crookes.

7. How are X-rays produced these days? What uses do they have in our modern society?

8. Why is it important for pregnant women not to have X-rays? Are there any other dangers associated with X-rays?

May cause leukaemia, as well as damage the developing foetus. An aim should be to avoid unnecessary exposure: remember how we used x-rays to check the fit of shoes in the early fifties? You don't? Oh well, ask around....

Röntgen (or Roentgen) received the Nobel Prize in 1901. When asked what he thought when he discovered x-rays, he replied:- "I didn't think - I experimented".

See also exercises 70, 71

SOURCE: Life Science Library : Matter ★★★

DISCOVERY OF THE INERT GASES 83a

Helium and gases related to it were hard to find and difficult to liquify. Called *inert* or *noble* gases because they "snubbed" other elements, they were tracked down in one of the great sagas of chemical detection.

Their trail was picked up in 1785 when Henry Cavendish, in an experiment with air, noticed that a small bubble, about 1/120th of the whole, would not take part in the chemical reaction. The importance of this observation was not realised for over 100 years.

In 1868, a French astronomer, Jules Cesar Janssen noticed a brilliant yellow line in the sun's spectrum. It was attributed to an unknown element, which was named helium after *Helios* the Greek word for the sun. Thirteen years later, an Italian Luigi Palmieri detected the same line in the effluvia of the crater of Vesuvius. An American chemist, William Hillebrand, subsequently isolated an inert gas with the same spectrum from a uranium mineral.

In 1894, two English men, J.W.S. Rayleigh and William Ramsay observed a mysterious gas in the air and analysed it with a spectroscope. This device identifies gases by the characteristic colour lines they show when an electric current passes through them. The gas, which seemed to have no chemical properties at all, revealed red and green lines never observed before. Rayleigh and Ramsay named it argon, "the lazy one".

From all the accumulated data, Ramsay then identified helium. In 1898 he discovered krypton, neon and xenon by liquifying air and examining the residue left when the oxygen and nitrogen were evaporated. The last inert gas, radon, was discovered by Ernst Dorn, a German, in 1900.

While he was in India, studying a total eclipse

Acceptable, according to the O.E.D.

Icelandic sagas (or stories or tales) usually involve long, heroic adventures.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the artic e? liquify (line 2), snubbed (line 2), sagas (line 3), element (line 11), effluvia (line 13), analysed (line 17), characteristic (line 18), properties (line 20), accumulated (line 22), residue (line 24).

2. What technique enabled the inert gases to be observed and identified? Spectroscopy

3. How were samples of the inert gases obtained? Reaction leftovers

4. What is meant by the expression "called inert or noble gases because they "snubbed" other elements (lines 2 and 3)?

5. Why was it difficult to isolate and identify the inert gases until over 100 years after they were first noticed? Small quantities, unreactive

6. Why did Ramsay refer to argon as a mysterious (line 17) gas? New, previously unknown

7. Draw up a table listing the inert gases and their dates of discovery.

8. In which year was helium first detected and identified on earth? 1881
Suggest a possible reason to account for the time lapse between the discovery of helium in the sun and its actual discovery on earth.

RESEARCH QUESTIONS

83b

9. Draw up a table of the inert gases listing the derivation of their names and what each means.

10. (a) What is a spectrum (line 10)?

(b) How is a spectrum obtained?

(c) To what uses is spectroscopy put today?

11. The inert gases are often referred to as the "rare" gases. Find out how much of each gas exists in our atmosphere.

12. In recent years some compounds of the inert gases were made. What are some of these and when were they first made?

9. Helium - Greek helios = sun
Neon " neos = new
Argon " argos = idle
Krypton " kryptos = hidden
Xenon " xenos = strange
Radon From RADium + the standard -ON ending.

(We used the Shorter Oxford)

10. See any simple text-book, see also our note to #71.

11. By volume in pure, dry air:
Ar 0.934 %, Ne 0.00182 %, He 0.00053, Kr 0.00012 %,
Xe 0.00009 %.

12. KrF_2, XeF_2, XeF_4, XeF_6, $XeCl_2$, XeO_3, XeO_4,
$XeOF_4$, $Xe(OH)_6$

W.J. Laidler and M.H. Ford-Smith "The Chemical Elements".

See also exercise 140.

WHOOPS!

★★

ACIDS

84

Acids are among the most useful and sometimes the most dangerous of chemical substances. Strong hydrochlorine acid, for example, is a deadly poison, but if people did not have a small quantity of this acid in their stomachs they would not be able to digest their food properly.

The word *acid* comes from the Latin word *acidus* which means "sour", because most acids have a sour taste. A way of finding out whether a liquid is an acid is to pour a little of it over some blue vegetable colouring matter, called litmus. If the liquid is acid the blue litmus will turn red.

Many people think that acids are corrosive or "burning" liquids. This is because the two most common acids - sulfuric acid (oil of vitriol) and nitric acid (*aqua fortis*) are very corrosive and burn skin, wool and cloth. However, many acids are not as corrosive as this, and many are solids, not liquids.

Although some acids cause serious burns and some are deadly poisons, others are harmless and even good to eat. Many of these take their names from the fruit or substance in which they are found. Citric acid comes from citrus fruits, malic acid from apples, tartaric acid from grapes and acetic acid is found in vinegar.

Acids which come from plants and animals are called organic acids, but not all are pleasant. For example oxalic acid (in rhubarb), and prussic acid (in bitter almonds and peach stones) are very poisonous.

Sulfuric, hydrochloric and nitric acids are the most important inorganic acids and they are used to make batteries, fertilisers, explosives and plastics.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   vegetable (line 7), corrosive (line 9), organic (line 19), fertilisers (line 23).

Zinc won't do - it gives hydrogen with NaOH sol'n! →

2. How could you determine whether or not a liquid was an acid?
   Litmus or other indicator
3. Although many acids are not corrosive, why do most people consider them so? The most common ones are.
4. What is the main difference between organic and inorganic acids? Contain carbon, originate in animals & plants

malus Latin word for apple-tree

tartar is the name of a deposit found in wine vats - potassium bitartrate. Possibly of Arabic origin, found in medieval Latin & Greek

acetum Latin for sour wine.

RESEARCH QUESTIONS

5. The origin of citric (from citrus fruits) is obvious, but what does malic have to do with apples, tartaric with grapes, and acetic with vinegar?
6. How are these acids made industrially?
   (i) sulfuric acid Lead chamber process, contact process
   (ii) nitric acid H_2SO_4 on $NaNO_3$ or KNO_3, or oxidation of NH_3 using a platinised asbestos catalyst.
   (iii) hydrochloric acid.
7. Describe in detail the uses of either hydrochloric or sulfuric acid.
8. Prussic acid is very interesting historically. For what purposes has it been used? What is its chemical name? What relation is there between prussic acid and Prussian blue?

6(iii) Conc. H_2SO_4 on NaCl, or combine H_2 & Cl_2 from electrolysis of brine.

7. HCl is used as a lab reagent, making gelatin & glue (see #87), pickling metals & cleaning bricks.

8. The literary successors of Conan Doyle love it ("... slowly he picked up the dead man's glass and sniffed warily. 'Bitter almonds' he nodded, 'this man was poisoned with Prussic acid'."). Used in USA death chambers. Prussian blue is a deep blue potassium and iron cyanide complex, first discovered in Berlin. We gather that Prussic acid may be obtained from Prussian blue.

★★

ALKALIS 85

Certain substances, which are called bases, can neutralise acids. This means that when they combine with acids, they form a salt and water. A base which dissolves in water is called an alkali. It will turn red litmus solution blue.

The word alkali comes from an Arabic word meaning ashes. People who lived a long time ago used the ashes of wood and seashore plants to make alkalis. Today alkalis are made in chemical factories.

Alkalis usually feel slippery and have a bitter taste. The strongest of them, called caustic alkalis, have a corrosive burning action on the skin and must be used very carefully. The most common alkalis are sodium, potassium, calcium and ammonium hydroxide, (Caustic soda, caustic potash, slaked lime and household ammonia respectively.

Caustic soda is one of the most important alkalis. It is a white solid which dissolves in water. It is used in making soap and rayon, and it is also used in the cotton industry. Caustic potash is used to make dyestuffs and some kinds of soap. Slaked lime dug into acid soil makes it more fertile by neutralising the acids. Household ammonia helps to remove grease and is useful in many cleaning situations.

Al kali or Al goliy, depending on your source. *

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of the following words as used in the passage?

   neutralise (line 1), dissolves (line 3), caustic (line 9), corrosive (line 9), slaked (line 12), fertile (line 17).

2. The passage mentions 5 properties of alkalis. List them.

3. Construct a two-column table. List the four alkalis mentioned in the passage in one column, and their uses in the second column.

2. Neutralise acids
Turn litmus blue
Feel slippery
Taste bitter,
Corrode skin.

RESEARCH QUESTIONS

4. What is neutralisation? Describe the process of neutralisation in detail, giving chemical equations.

5. Describe in detail the manufacture of one of the following: soap, sodium hydroxide, ammonia.

6. Find 5 other uses of sodium hydroxide and ammonium hydroxide not mentioned in the passage.

$NaOH$ - petroleum refining, paper manufacture, toilet & drain cleaners, wool scouring

NH_4OH - refrigerant (as NH_3!), explosives manufacture, fertiliser manufacture, nitric acid manufacture, raw material for other syntheses

* Why is the symbol for potassium K? The Latinised version of al kali is kalium. But Mr. Davy was an Englishman (well, Cornish, anyhow) and he called it pot ash. That Latinises nicely to potassium....

See also exercise 106

★

CELLULOSE 86

Cellulose is a word meaning "made of cells". It is a substance found in nearly all plants. The softer parts of plants such as the pith in the centre of the stem, are made up of cellulose. It makes plants pliable so that they can be bent without breaking.

Cellulose is made of carbon, hydrogen and oxygen. These elements are obtained by the plant from the air and water. The plant makes sugars which flow through every part of the plant as sap. This helps in growth and repair. Part of the sugar in the sap is changed to cellulose and used for making the walls of new cells and for repairing parts of the plant that have been injured.

And termites and cockroaches have handy protozoa.

Many foods have a lot of cellulose in them. Foods such as lettuce, celery and bran contain cellulose. Animals such as the goat and the camel have certain bacteria in their stomachs which help them to digest cellulose. The human stomach, however, doesn't have these bacteria, so we cannot digest cellulose. It is useful to humans as roughage.

Only nature can make cellulose. Man cannot make it. Man uses it in many different ways, because it is a valuable raw material. It is used to make cotton, linen fibres, thread, rope and twine and thousands of other substances. It can be used to make explosives, photographic films, varnishes for wood and metal, rayon and plastics.

Large quantities of cellulose are made into paper, parchment and *papier mâché* and cardboard. Cellulose is quite durable: after a plant dies, it is one of the last parts to decompose. This property is one of the main reasons why it is so useful to Man.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words or terms mean as they are used in the passage?

   pliable (line 3), digest (line 12), raw material (line 16), durable (line 21).

Growth & repair — 2. For what reason(s) does a plant need cellulose?

Clothing, paper etc. — 3. Why is cellulose such a useful substance for Man?

Probably as paper — 4. What is the main use to which Man puts cellulose?

Parenchyma cells - no lignin! 5. What is the pith of a plant? What does it consist of?

RESEARCH QUESTIONS

6. If cellulose contains the same elements as sugars, which are sources of energy for Man, why isn't cellulose a similar source of energy? We lack the necessary enzymes.

7. What is roughage (line 14)? Why is it useful to Man? Supplies the bulk to clear the large intestine

8. What is sap (line 7)? Water, minerals, sugar etc.

9. What makes sap move through plants? Root pressure, active transport, transpiration effects.

10. What is the connection between car tyres and sap? Rubber comes from the sap of *Hevea brasiliensis* *

11. List five other uses Man has for cellulose. Do not mention any from the passage. Anything goes!

12. What are the differences between thread, rope and twine (line 17 (line 17)?

13. What is *papier mâché* (line 21)? What is it used for? Where does the name come from?

12. Thread is one or more filaments twisted, twine is usually two or more, rope is twine with connotations of strength

13. French for "mashed paper". Egg boxes, puppets, models.

* Try "Couchie - the weeping wood" by Peter Mason: book $4.95, tapes $12.45 from the ABC. Who says scientists aren't literate?

See also exercises 59, 130.

SOURCE: Children's Britannica ★★

GELATIN * 87

A pudding made from the hoofs, bones and horns of animals does not sound very tempting, but when it appears on the table as a jelly you probably enjoy eating it very much.

The gelatin from which such a jelly is made is obtained by first dissolving from the hoofs, bones and horns everything but the sticky substance called cartilage. The cartilage is then boiled until it dissolves. It is then a crude form of gelatin. Further refining and filtering in alcohol makes it a purer gelatin. This solidifies when cool and can be made into the powder or sheets sold as gelatin. When this is coloured and flavoured with fruit juices and then dissolved in warm water, it sets to a clear sparkling jelly on cooling.

Gelatin belongs to the protein class of foods so it is easily digested. It is used chiefly in jellies, and in soups, ice cream, chocolate fillings and preserved meats . It is also used as a coating for pills, and in cough sweets and throat medicines. Other uses include making glue and photographic films.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   dissolving (line 5), crude (line 7), refining (line 7), filtering (line 7), class (line 12), digested (line 12).
2. Which part of the hoofs, bones and horns is actually used to make the gelatin? Cartilage
3. Why is gelatin good for invalids? Give a second reason, not mentioned in the passage. Protein source, no chewing, easily digested.
4. Why is gelatin used for so many foodstuffs? Available, pleasant, cheap, easy to handle

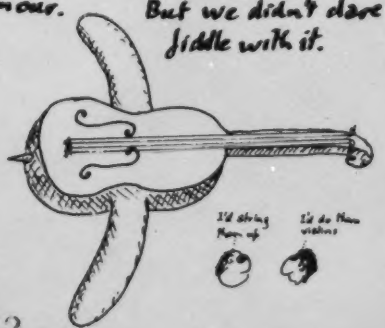
RESEARCH QUESTIONS

5. Find out how gelatin is used to make photographic films. The emulsion is held in a gelatin matrix
6. In the manufacture of the gelatin, what is the purpose of the filtering in alcohol (line 7)?

* The OED says "gelatine" is the popular form, and the scientific form is "gelatin".

The management wish to apologise for this viol humour. But we didn't dare fiddle with it.

Aeroplane celli



Some people may prefer to use the original text, others might prefer to use the relevant part of programme four in the series (if they can obtain a legally made copy!).

★★★

SOURCE: Adapted from J. Bronowski, 'The Ascent of Man', 1976, pages 125-133.

88a

COPPER AND IRON

Almost ten thousand years ago, not long after the beginning of the settled communities of agriculture, men in the Middle East began to use copper. But the use of metals could not become general until there was found a systematic process for getting them. That is the extraction of metals from their ores, which was begun some seven thousand years ago, (5000 B.C.) in Persia and Afghanistan. At that time, men put the green rock malachite into the fire and from it flowed the red metal, copper. They recognised copper because it is sometimes found in raw lumps on the surface, and in that form it has been hammered and worked for over two thousand years already.

Metal became the backbone of civilised life. Man had at his control a material which can be moulded, drawn, hammered, cast; which can be made into a tool, an ornament, a vessel; and which can be thrown back into the fire and be reshaped. It has only one shortcoming - copper is a soft metal. As soon as it is put under strain, stretched in the form of a wire for instance, it visibly begins to yield. The coppersmith was faced with a robust problem, which is that copper will not take an edge.

The ancient smelters found an answer to this problem: namely, that when to copper is added an even softer metal, tin, an alloy is made which is harder and more durable than either - bronze. The working of bronze reached its finest expression in China. It had come to China almost certainly from the Middle East, where bronze was discovered about 3800 B.C. The high period of bronze in China is also the beginning of Chinese civilisation - the Shang dynasty, before 1500 B.C.

The proportions of copper and tin that Chinese used are fairly exact. Bronze can be made from almost any proportion between, say, 5% and 20% of tin added to the copper. But the best Shang bronzes are held at 15% tin, at that proportion bronze being almost three times as hard as copper. Bronze was used in making vessels for wine and food.

Because it is much more difficult to extract from its ores than copper, smelted iron is a much later discovery. The wide use of iron was initiated by the Hittites near the Black Sea around 1500 B.C. - just the time of the finest bronze in China, the time of Stonehenge.

Within five hundred years, by 1000 B.C., steel(the alloy of iron) was being made in India, and the exquisite properties of different kinds of steel came to be known.

Iron is a later discovery than copper because at every stage it needs more heat - in smelting, working and, naturally, in processing its alloy, steel. (The melting point of iron is about 1500 °C, almost 500°C higher than that of copper.) Both in heat treatment and in its response to added elements, steel is a material infinitely more sensitive than bronze. In it iron is alloyed with a tiny percentage of carbon, less than 1% usually, and variations in that dictate the underlying properties of the steel.

Being harder than either copper or bronze made steel superior especially in the making of weapons for these could then be used to more easily defeat opposing armies.

The sword, for instance, is the weapon of the Samurai. By it they survived endless civil wars that divided Japan from the twelfth century on. Everything about them is fine metalwork: the flexible armour made of steel strips, the horse trappings, the stirrups.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words mean as used in the article? agriculture (line 2), systematic (line 4), ores (line 5), cast (line 12), robust (line 17), alloy (line 20), durable (line 21), vessels (line 31), smelted (line 33).

2. For how long had man been using copper, before some way was devised for extracting it from its ore? Lines 1, 5

3. Why had metal become "the backbone of civilised life" (line 11)?

4. What evidence in the article indicates that copper is *malleable*? cf mallet malleus (in ear) Line 12

5. What are some of the disadvantages of copper? Lines 15, 18

6. (a) What is bronze? Lines 20, 28-30
   (b) How did bronze overcome some of the disadvantages of copper? Line 21

7. Why was iron discovered at a later date than copper? Line 32

8. How many years passed between when copper was first extracted from its ores to when iron became widely used? 3500 yrs (Lines 6 & 34)

9. Fill in the blanks:
   (a) An ore of copper is malachite (L. 7)
   (b) Bronze is to copper as steel is to iron. (L. 36)
   (c) Bronze contains copper and tin (L 20)
   (d) The melting point of copper is about 1000 °C. (lines 41-2)

10. Why is steel "a material infinitely more sensitive than bronze" (lines 43 and 44)? More adjustably variable (see 44-46)

11. Why were iron and steel considered superior to copper and bronze? Harder, sharper

12. What advantage would an army with steel weapons have over one which did not have steel weapons? They could chop them into little bits. *

RESEARCH QUESTIONS

13. Describe how copper and iron are extracted from their ores today.

Heat the sulfide to obtain the oxide. Dissolve in acid & electrolyse, producing pure-ish copper on a copper cathode. Zone refining ("Scientific American", Dec. 1967, p. 62) can improve the purity.

Iron is extracted from oxides (haematite, limonite, magnetite, siderite) by reduction in a blast furnace, heating with coke (usually) and limestone. CO & CO_2 go off, slag floats to top, pig iron is tapped for conversion to steel later.

* The Norsemen used bog-iron ore and charcoal. The makers of the Norse sagas dwell lovingly on the way sticking-out-bits (arms, legs, heads) could be lopped off. De gustibus non disputandum est....

See also exercises 27, 28, 29, 30.

★★

SOURCE: Science as Part of Education, Aust. Sc. Tch. Jour., Vol. 10, No. 2, August, 1964.

Try these for question 3! (not underlined on the first master)

SIR MARK OLIPHANT SAID THIS ABOUT LEARNING SCIENCE 89

"However the weaving of science into the cultural background of every man and woman will have far more important results than this. It will enrich the life and thought of every citizen, and will greatly increase his emotional involvement in the world in which he lives. Knowing how greatly men of every nation, creed and colour contribute to the advance of natural knowledge, he will be less conscious of the barriers of politics or of language than are those with knowledge only of their own particular culture. His respect for mankind as a whole will change the complexion of international and inter-racial relations. In short, science offers the best hope of collaboration between all peoples in common enterprise for the good of all. It is the greatest civilizing influence of all time, the natural bulwark against war, as well as by far the most important activity relieving mankind of famine, want and drudgery."

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words mean as used in this article? weaving (line 1), creed (line 5), culture (line 9), complexion (line 10), collaboration (line 11), bulwark (line 13), want (line 15).

A rare example of a question which asks for extrapolation

2. What do you think Sir Mark Oliphant meant by the word *"this"* when he said "the weaving of science ... will have far more important results than this." (lines 1 to 3)?

technological benefits

3. What are the benefits, as seen by Sir Mark Oliphant, of studying science? See above

RESEARCH QUESTIONS

4. Do you agree with Sir Mark Oliphant's view? Explain what you think of the value of studying science.

5. Do you agree with the statement, "science offers the best hope ... for the good of all." (lines 11 and 12)? Explain your view.

6. (If you wish to add it) What was Sir Mark Oliphant, when he wrote this? What position did he later hold?

Nuclear physicist, later Governor of S.A.

★

HOW DO SCIENTISTS EXPLAIN ELECTRICITY? 90

A perspex rod is believed to be made of an equal number of positive and negative charges. This makes the rod normally neutral. The negative charges are called "electrons" and when the rod is rubbed with silk, the electrons are transferred from the rod to the silk. This makes the rod positively charged, because it now has more positive charges than negative charges. The electrons are small, even smaller than atoms, so that we do not see them being transferred. An ebonite rod behaves in a similar way when it is rubbed with a flannel. But this time, electrons are transferred from the flannel to the ebonite and the ebonite becomes negatively charged.

Now an electric current is believed to be a flow of electrons along a wire. Of course, no flow is possible without a circuit and no flow is possible unless there is a power source to provide a voltage. Sometimes, we can imagine a current in a wire to be like water in a tube. No water will flow unless we have a pump, and no current will flow without a voltage. That is, we can think of voltage as an electrical pump and we are measuring the pressure of the pump when we measure voltage with a voltmeter. Similarly, we can imagine we are measuring the amount of water flowing when we measure the current with an ammeter.

'Perspex' means see-through! Now you know what it is to be perspicacious!

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. Explain the meaning of each of the words underlined in the passage:

   neutral (line 2), transferred (line 4), similar (line 7), possible (line 11), circuit (line 11), source (line 12).

2. Which kind of rod is rubbed with silk? perspex (but either is charged by silk)
3. Which kind of rod has a negative charge? Flannelled ebonite
4. What do we call a flow of electrons along a wire? Current
5. What is needed before a current will flow? Pole-tial difference
6. What do we measure voltage with? Voltmeter (not voltameter!)
7. What do we measure with an ammeter? Current (not egotists)
8. What can voltage be thought of as? (Riskily!) as a flow of water.

RESEARCH QUESTIONS

9. What is an electron? Wave-icle? -1.6×10^{-19}C, 9.31×10^{-31}kg.
10. Thinking of electric current as water in a pipe is called an analogy. What is an analogy? See also Q.5, exercise 124, Q.5 exercise 142

If you like your physics with a bit of class: try Robert A. Millikan's "The Electron", published 1917, reprinted by Phoenix.

See also exercises 48, 101

One REAL problem for the budding physicist: what is the difference between momentum & kinetic energy? Maybe this will help by bringing the issue into the open...

SOURCE: "Energy", Life Science Library, 1965. ★★★

This spelling is more common in the U.S.A. We use Leibniz more commonly. The first has the advantage of indicating the correct pronunciation. The second is that used by Leibniz.

WHOOPS!

MEASURING FORCE 91a

Leibnitz, in his attempt to work out some yardstick for the measurement of force, turned to Galileo's experiments with falling bodies. The Italian had found that all objects fall at the same speed no matter how big or heavy they may be. However, Leibnitz realized that an object weighing a tonne would do a lot more damage when it hit the ground than one weighing a kilogram. Here was a way to measure force. Simply work out a way to measure how big an impact an object will make. It is obvious, Leibnitz said, that the impact depends on two things - how much the object weighs and how far it falls.

But suppose you are not interested in the force exerted by a *falling* object. Suppose the object you are interested in is rising into the air, or rolling along level ground. Where does height fit into this? Leibnitz realized that it wasn't really the height that was important. It was how fast an object was falling. This of course is related to the height from which it falls. The further it falls, the faster it goes. Leibnitz modified his formula to say that the measurement of force depended on the weight of an object and how fast it was going when it was stopped.

He invited a name for the impact. He called it the *vis viva*. At the same time, Christian Huygens was pursuing a related line of inquiry. He spent tedious hours studying what happened when two moving objects collided. In 1699, the results of his observations were published. He declared that in a collision such as might take place between two perfectly hard billiard balls, the sum of the *vis viva* in each of the balls is the same before and after impact. One ball might be slowed by the collision but the other would be speeded up. The sum of the two *vis vivas* would always be the same.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in this article? yardstick (line 1), speed (line 3), force (line 6), impact (line 7), modified (line 16), tedious (line 21).

2. How did Leibnitz measure force?
Lines 5-8

3. What caused Leibnitz to modify his formulae (line 16)?
Lines 13, 14

4. The expression weighing a tonne (line 5) is actually wrong. Why is it incorrect and what is a correct statement in this case? A mass of "a tonne" is not a weight

5. In the situation described, was it essential that the colliding objects be like perfectly hard billiard balls (line 24)? Explain. No, if we speak of momentum. Yes if we speak of kinetic energy

6. What, in modern day terms is *vis viva* (lines 19 and 24)?

7. Leibnitz could be talking about kinetic energy or momentum or both. What is he talking about? Given evidence from the passage which enables you to make this implication.

6 & 7 This is worth discussing in class - the two questions are the same.

91b

8. The sum of the two *vis vivas* would always be the same (lines 26 and 27). Restate this in a more familiar form.

Laws of conservation of momentum and energy

9. Is Leibnitz correct when he says that the force exerted by a falling object depends on <u>how much the object weighs and how far it falls</u> (lines 8 and 9). Support your answer with physics you have studied. Is this really the same as the *vis vivas* of Leibnitz? Explain your answer.

$KE = mgh$

See also exercises 56, 60, 94, 96, 97, 98, 129.

SOURCE: The Bulletin, 1978, date unknown. ★★

92a

THE REALITY OF THE SMILING AUSTRALIAN

What is in the Australian smile? Fifteen million rotting and decayed teeth for starters, two million cases of mild or serious gum infection and two million sets of false teeth according to the experts.

The dental professional remains gloomy about the statistics. For years they've been trying to convince people that apples, carrots and celery don't clean the teeth, that religious scrubbing is not the answer to tooth decay and that fluoride does have benefits for everyone over the age of 12.

The Dental Health Education and Research Foundation at the University of Sydney has also been trying to convince people that dentists can guarantee 100 percent protection against cavities, provided that patients follow certain rules. These are cleaning teeth properly, using dental floss, and special soft tooth picks daily and a special paste once a week. The floss and tooth picks are necessary because toothbrushes cannot reach effectively into the cracks between the teeth. If you care for teeth by this approved method, don't eat sweets and visit a dentist regularly, your teeth should remain faithful for life.

Even if a tooth becomes dislodged or lost during an accident, it can be saved by placing it immediately back into the socket. If it is put back within 30 minutes, there is a 90 percent chance of it being saved, because the fibres attaching it to the bone re-attach themselves in a natural healing process. The longer the delay, the less chance of saving the tooth. If it hasn't been replaced for two hours, it has only a 5 percent chance of being saved.

If, however, the stage of prevention is past, cure is still possible. Dentists are perfecting tooth implant operations for people who can't or won't wear dentures, magnetic false teeth for those who can and will, and cosmetic remodelling for people who just want a nicer smile.

The tooth implantation method is being pioneered around the world. One such method uses thin blades of titanium which are placed in grooves cut in the jawbone. If the operation is skilfully performed, the bone grows back around the titanium bracket, keeping it firmly in place. The gum also grows back and the false teeth are cemented into and between prongs or posts which are the only extension of the bracket into the mouth. Implants are costly and sometimes rejected, but they can be a boon to people who have trouble with dentures.

Magnets are being used to solve the problem of loose dentures. Dr. B.R. Gillings, a senior lecturer in the Department of Prosthetic Dentistry at the University of Sydney, has fitted patients with dentures held in place by tiny strong magnets. This method, because of its low cost and simplicity, can be used in cases where more expensive and complicated attachments are unsuitable.

Then there is cosmetic dentistry, which is expensive, but rapidly growing in popularity. Thousands of Australians are paying up to $5 000 to have naturally crooked or stained teeth capped or crowned in search of the good looks ideal.

But one word of warning about modern dentistry. New techniques and equipment have increased the risk of accidental injury and infection to patients. Possible hazards include lacerations, flying fragments disappearing down the patient's throat, or landing in the dentist's eye.

New furniture which enables the dentist to work seated increases the risk of instruments falling into unlikely places. The *Medical Journal of Australia* reported in July that suture needles, a burr, a drill, amalgam fillings, inlays and teeth have been recovered from the stomachs and lungs of dental patients.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

92b

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words mean as used in this article? infection (line 3), religious (line 6), cavities (line 11), floss (line 12), implant (line 26), pioneered (line 29), titanium (line 30), prosthetic (line 38), laceration (line 49), suture (line 53), burr (line 53).

2. What do you think the author meant by the heading of this article, 'The Reality of the Australian Smile"?

3. What percentage of the Australian population wear false teeth? ~13%

4. What are the special rules people need to follow to have 100% protection against cavities? Lines 12-14 (or remove all teeth - this has been done in the past!)

5. What is "dental floss"? Nylon thread of many fine fibres pulled between the teeth.

6. Why should dental floss and tooth picks be used when cleaning teeth? Lines 14 & 15

7. What should you do when a tooth is forced out of position in an accident? Why is it important that you act immediately? Lines 20-24

8. What is "titanium"? Why is it used in dentistry? A metal. We assume that it is biologically inert (?)

9. What is the "tooth implantation method"? Lines 30-34

10. When would magnets be used in dentistry? Lines 37-42

✱11. What would dentists do in "cosmetic dentistry"? Repair for the sake of appearance.

12. Are modern techniques in dentistry absolutely safe? Explain, giving examples. Last two paragraphs. Stress "absolutely"

RESEARCH QUESTIONS

13. Amalgam is used extensively in dentistry: what is amalgam? What amalgam(s) are used in dentistry? Why are they used? What are some of the hazards associated with their use?

Soft at first, then hard. 25% Zn, 25% Sn, 50% Hg. Also Cd and Cd-Sn amalgams used, as well as gold and copper. Metal poisoning if swallowed while soft.

✱ Be on the look out for answers such as "use lipstick for tooth-paste": the word "cosmetic" has been appropriated by one industry. Here is a good chance to point to an example of differences between technical usage and common usage. See passages 87 and 91 for other examples. P.S.: 68 also!

Class discussion topic: the value of cosmetic surgery + dentistry: there can be definite psychological and economic advantages.

See also exercise 97.

TWINS ★★★ 93

There are two different kinds of human twins: fraternal twins who develop from two separately fertilised eggs, and identical twins who develop from the same egg. In the last case, the fertilised egg splits completely apart as it doubles.

Fraternal twins are as much alike as ordinary brothers and sisters in a family. They have different complements of chromosomes. However, identical twins look alike and are the same sex. They have identical sets of chromosomes.

In fact, the environments are very rarely "very different". See below.

Sometimes identical twins are reared apart. This can happen when they are orphans and are separated at birth. In these cases, the twins are exposed to very different environments. However, these different environments act on the same hereditary background. Therefore the importance of heredity and the environment on human development can be studied.

If the twins have not been separated, a comparison between the two types of twins can be made. That is, the effect of the same environment on identical twins can be compared with the effect on fraternal twins.

In this way a lot has been learnt about the way twins behave. The studies indicate that identical twins do behave in very similar ways. The behaviour of fraternal twins is not as markedly similar. However, if identical twins are separated, their behaviour differs more than those of identical twins not separated.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article?

   fraternal (line 1), fertilised (line 2), chromosomes (line reared (line 9), exposed (line 11), environments (line 11) hereditary (line 12)

2. What is the difference between *fraternal* and *identical* twins?
   See lines 1-4

3. What was the purpose of these studies?
   To compare the effects of "nature and nurture"

4. Three experimental situations are described in the passage. For example, one was the effect of the environment on identical twins reared apart. What are the others?
   Fraternal twins together, identical twins together

RESEARCH QUESTIONS

5. Many studies have been made about the effect of schooling on intelligence. Some people argue that intelligence is mainly inherited. Others argue that intelligence is developed by schooling. Still others argue that it is a combination of both.
   Using psychology books, outline two investigations involving the use of fraternal and identical twins that inquire into this problem.

Watch out for references to the work of Cyril Burt: his data on twins and intelligence are now known to be addled, bent, cooked, doctored and maltreated right across the alphabet. This has only happened in the last few years: Oliver Gillie, Sunday Times 27-10-76, also a book with Hart-Davis, McGibbon book Who do you think you are? See also New Scientist 28-10-76 p. 197, 11-11-76 p 330, Phi Delta Kappan Feb 1977, 469-471 and 492 for two views.

See also exercises 56, 60, 61, 92, 96, 97, 98.

★

VITAMIN C CONTROLS PRICKLY HEAT 94

Australian soldiers serving in Malaysia in the 1960s faced a medical problem. Their white skin was not used to the tropical heat and they suffered many skin disorders. The worst disorder was prickly heat. This type of rash was also thought to lead to other skin disorders such as ringworm, impetigo and athlete's foot. Doctors working in the tropics believed that lack of sweating caused prickly heat. They were not sure how to best treat this problem but decided to experiment with large doses of harmless ascorbic acid (Vitamin C).

The doctors planned two experiments. In the first experiment they used sixty soldiers' children who had severe prickly heat. Thirty of these were given large amounts of Vitamin C for seven days. In this time twenty six were cured. The second thirty were given a placebo in place of the Vitamin C dose. Only six of these showed improvement.

In the second experiment, twelve Royal Australian Artillery volunteers serving in Malaysia were used. Prickly heat was induced by wrapping the limbs of these volunteers in polythene sheeting for 48 hours. The soldiers were then treated with ascorbic acid. Ten of them were cured.

Although this treatment worked well, doctors were not sure why this was so. They suggested that the vitamin C was excreted in sweat and that this prevented sweat gland fatigue. Until further research takes place, however, it cannot be certain that this is the right explanation.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article?

   disorders (line 3), impetigo (line 5), placebo (line 12)
   induced (line 15), excreted (line 19) fatigue (line 20)

2. What caused the Australian soldiers to get prickly heat in the case of
   (i) the serving soldiers; and Line 2
   (ii) the volunteers. Lines 15 & 16

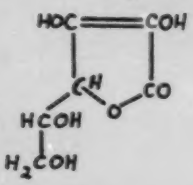
3. In the experiments which were done, how many people were treated (total), how many were cured or showed improvement, and how many of those treated were not cured? 42 36 6

4. Three hypotheses have been made in the passage. Rewrite enough of each so that it can be identified. (i) lack of sweating ... (line 6)
   (ii) vitamin C can help cure (lines 7 & 8) (iii) Vitamin C was excreted ... (Lines 19/20)

5. What conclusion could be drawn from these experiments?
   Vitamin C appears to aid in effecting a cure

6. Where is ascorbic acid found naturally? Is it synthesised by man? See if you can find out its chemical structure and copy it out. Do you understand what this means? What do we use ascorbic acid for? ← RESEARCH QUESTION!

Orange & tomato juice, capsicums, potatoes, spinach, many other foods. Non-primates make their own from glucose, but primates have lost the ability. About 50 mg daily are needed to prevent scurvy.



See also exercises 70 & 96.

★★★

SCIENTISTS FIGHT NEWCASTLE DISEASE 95

Newcastle Disease Virus (NDV) affects the respiratory tract and the nervous system of poultry. The disease appears with strains varying from mild to severe strength. The severe strains kill up to 100% of infected poultry. This causes hundreds of millions of dollars damage annually throughout the world.

Laboratory experiments showed ultraviolet radiation (UV) kills NDV in a matter of seconds. Applied research was needed, however, before the full impact of UV treatment could be known. Two Israeli scientists, Perek and Heller carried out this research.

During the first days of their lives, baby chickens may withstand slight infection of NDV because they receive some antibodies from their immunised mother through the egg yolk. However they gradually lose these inherited antibodies. Until the age of 21-28 days, vaccination of chickens is pointless as they are not able to produce sufficient antibodies in their tissues to counter a massive infection. It is also possible that the immunity young chickens have inherited through their antibodies, might be affected by too early a vaccination.

Under normal conditions chickens may be exposed to massive infection from NDV being carried through the air from infected poultry up to 4 kilometres away. Perek and Heller decided to try and control NDV by using continuous radiation from UV lamps of 253 nm wavelength. In the experimental houses, chicks from 1-60 days old were subjected to continuous UV radiation while in the adjacent control room, no radiation was installed. In each of the rooms a cage containing NDV-infected birds was placed high on the wall. The birds in the cage sneezed and coughed, spreading the drops from their beaks all over the room. When they died, they were replaced by other NDV-infected birds. The experiment lasted 22-26 days until the control groups died by NDV infection. No birds in the radiated groups showed signs of the disease and none of them died.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article?
virus (line 1), strains (line 2), ultraviolet (line 6) antibodies (line 11), immunised (line 11), inherited (line 12), vaccination (line 13), radiation (line 21).

WHOOPS!

2. How is NVD communicated between chickens? Lines 18-20

3. What reasons have been given for the failure of vaccination of chickens against NDV? Lines 13-17

4. How was this particular experiment set up and controlled? Lines 20-27

5. What conclusion could be drawn from the results of this experiment? The treatment appeared to work.

6. If vaccination didn't work well with chickens until they were 21-28 days old, why weren't they vaccinated after reaching this age? Lines 15-17.

7. In immunisation, specific antibodies are injected to produce immunity. In vaccination, weakened strains are injected to stimulate production of antibodies.

RESEARCH QUESTIONS

7. What is the difference between *immunisation* and *vaccination*

8. Who first discovered the principles of immunisation and vaccination? Briefly describe the series of events or experiments which lead to the discoveries.

* Jenner, but read up on variolation before judging him

9. List 3 diseases in man which can be avoided, or at least lessened by
(a) immunisation and poliomyelitis, tetanus, diphtheria
(b) vaccination. rabies influenza, smallpox
How are the immunising or vaccinating chemicals for each of the diseases you mentioned obtained? Which scientists were responsible for the discovery or development of each?

* Variolation: if a child (or adult) is certain to catch a disease, ran the argument, why not get it while he/she is healthy. This was standard practice in Jenner's time – see opposite. What Jenner did was to vaccinate before variolating in the normal way. So don't jump to the conclusion that his act was unethical. Now read #96.

Sit back and relax. Do we have your full attention? Good. Now think about this: children will die this year because they were not immunised. Their parents will say "We didn't know that it was still needed". Hence question 7, which is an attempt at consciousness-raising. Please use it, or at least refer to it.

See also exercises 56, 94, 97, 98. ★★

IMMUNITY TO DISEASE 96

At the beginning of the 18th century, Lady Montagu returned to England with some surprising news. While in Constantinople she had seen parents deliberately expose their children to the dreaded smallpox disease. This had not led to the children's death. Quite the opposite had occurred. The exposed children became immune to the smallpox. From this start, it was gradually realised that those who survived an infectious disease rarely caught that disease again.

How does the body develop this immunity to disease? When a disease attacks a body it is rather like a war. On the one hand there are the invaders. These are chemical components of the disease called antigens. On the other hand there are the body's defenders. These are called antibodies. The antibodies attempt to destroy the antigens. If they succeed the disease is conquered; the war is over.

Some infectious disease are very dangerous. These include diphtheria, poliomyelitis, whooping cough and tetanus. If they attacked and the body were not prepared, death or serious illness could result. To make the body ready you prepare it against each disease in advance. To do this you inoculate with vaccine. This puts the body in contact with a mild form of each disease. The body reacts by producing antibodies. These antibodies give immunity against future serious attack by that disease. Health authorities in Australia make such vaccinations readily available.

This describes variolation - see the note to exercise 95.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

inoculate: originally to put in the eye (oculus) - hence the spelling.

1. What do these mean as they are used in this article?

   expose (line 3), dreaded (line 3), immune (line 5), infectious (line 7), antigens (line 11), antibodies (line 12), inoculate (line 18), vaccine (line 18).

2. What observations led to the idea of immunisation? Lines 2-7 *

3. How does the body combat disease? Lines 8-13

4. Why is immunisation necessary? Lines 14-17

RESEARCH QUESTIONS

Smallpox - virus
Diphtheria - bacterium
Polio - virus
W. cough - bacterium
Tetanus - bacterium

5. What is the cause of each disease mentioned in the article. Describe how immunity to each is obtained.

6. What is the *Triple-antigen* which is given to all babies by health clinics in Australia? Tetanus, diphtheria, whooping cough

7. Some medical authorities have suggested that immunisation can lead to over-confidence. If nobody has children dying of these diseases, then other people will not have their babies immunised. Find out:

   (i) How many babies in your area have been immunised;
   (ii) If possible, why they have not been immunised; and
   (iii) What is being done locally to encourage parents to act on this matter.

And in what languages? You could try liaising with your local hospital or baby health centre sister here...

* This description is less than complete - many of the variolated children died, but the chances were better. This was not classic immunisation as we know it, but it is worth wondering: might they not have chosen as sources of infection, those with mild doses? Perhaps attenuated strains were selected quite unthinkingly....

See also exercises 93, 94, 96, 98, 129

★★★

DIABETIC MICE AND HUMANS 97

Laboratory mice with hereditary diabetes resembling the human diabetes disease have been discovered. To have diabetes in full form, the mice must inherit the gene from both parents. Such mice, however, are infertile. Consequently a special ovary-transplantation technique has to be used to keep the diabetic mouse line from dying out. As the diabetic female's egg cells carry the diabetic gene, her ovaries are transplanted to a healthy female. This healthy female is then mated with a male that is fertile because he carries only one diabetes gene. About half the mice born of such matings carry two diabetic genes and consequently develop the disease.

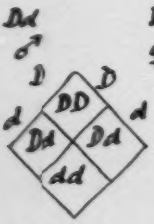
At first the mutant mice appear to be normal but soon they get fat. In spite of fasting and losing weight, and so lowering their blood sugar levels, they soon regain weight and blood sugar levels once their food intake is restored. Later, as the disease becomes rampant, they lose weight drastically as happens with human diabetes. Between 3 and 6 months of age the mice enter a terminal phase and usually die.

There are other ways in which the animal disease parallels the human disease. These ways include sensitivity to stress, excretion of large amounts of sugar in the urine and abnormal changes in the pancreas.

Some of the diabetic mice have responded to insulin treatment but the proper dosage remains to be worked out. Attempts are being made to prolong the animals' lives so that degenerative changes in the pancreas and other organs can be studied. One animal has lived nearly a year. Most of them, however, die after six months.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? hereditary (line 1), gene (line 3), infertile (line 4), consequently (line 4), ovaries (line 6), mutant (line 11), rampant (line 14), terminal (line 16), insulin (line 21), degenerative (line 23).
2. What are the symptoms of diabetes in mice? See lines 4, 11, 15 & 16
3. In what way(s) does the disease resemble diabetes in humans? See lines 15-20
4. For what reason is the insulin treatment not totally successful in prolonging the lives of mice? See line 22 for a partial answer to this.
5. Is the diabetic gene in mice dominant, recessive or neither? Give reasons for your answer. Recessive - see lines 1-3
6. Show, using conventional gene diagrams how mice with two diabetic genes can arise from a male and female each having only one gene for diabetes.



You may need to explain the logic of this.

RESEARCH QUESTIONS

7. There is an error in science in lines 9 - 10. Show how this is incorrect and rewrite it correctly. A pedantic point: "allele" should replace "gene".
8. What is diabetes? What causes it? How is it treated? What are the consequences of diabetes to a sufferer? See below
9. What is an ovary-transplantation? Why is it done in the case of mice? Homozygous females are sterile, but their ovaries, producing ova with the gene, work in normal females.
10. Why are these experiments being carried out? Is it cruel to use laboratory animals for such experiments? Is it justified? A good one for discussion. BUT DON'T LET IT GET OUT
11. Where are the Islets of Langerhans? Who was Langerhans? Of the

Diabetes mellitus results from the failure of the body to maintain a proper glycogen - blood sugar balance. Students should know about insulin shock and how to deal with it.

Diabetes insipidus is caused by a pituitary malfunction, causing urine production. (The word "diabetes" means 'a siphon').

See also exercises 60, 96, 97.

★

DISEASES CONNECTED WITH BLOOD 98

Modern man has overcome many diseases that killed earlier man. Such diseases as diphtheria are a thing of the past. But modern man is now faced with other diseases which are just as deadly. Many of these modern diseases are connected with the heart and blood circulation. In fact, heart disease is the most common cause of death in Western countries, such as Australia and the United States.

The most common of these new disorders are high blood pressure, hardening of the arteries, and heart attacks. These disorders are caused by such things as over-work and stress, lack of exercise, over-eating and poor diet. All these things are each person's responsibility and are completely in your hands as an individual, because you decide what food and exercise you take.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   overcome (line 1), deadly (line 3), circulation (line 4), Western (line 5), disorders (line 7), lack (line 9), individual (line 11).
2. Name a disease which is now hardly known at all. Diphtheria.
3. Which is the most common cause of death in Western countries? Heart disease.
4. Name another Western country other than Australia. U.S.A., Canada, EEC countries, New Zealand ....
5. Name two disorders which can cause heart disease. Lines 7 & 8
6. Name two causes of these disorders. Lines 9 & 10

RESEARCH QUESTIONS

7. What can you do to prevent heart disease for yourself? Sensible diet, regular exercise, don't smoke, avoid stress.
8. How many people die of heart disease in Australia each year?

The "Vital Statistics" chapter of the Australian "Year Book" includes a section on mortality. Students may need help in interpreting the "medical" language, although "arteriosclerotic heart disease" and "degenerative heart disease" should be fairly obvious. The bible is complex.

See also exercises 100, 103, 102, 104

Some of your students won't understand "per".

WHOOPS!

THE SENSES AND THEIR LIMITS 99

As we have seen, our senses can be fooled in optical illusions. This means that we cannot always rely on our senses and that sometimes we need to make measurements using measuring instruments such as rulers.

Not only that, but our senses do have limitations. That is, they have lower and upper limits. For example, the approximate range of hearing of the human ear is from 20 (Hertz) to 20 000 (Hertz) (Hertz is a unit meaning cycles per second). Outside these boundaries, we are unable to hear.

However, our senses are a very great help, and we find no problem in sorting out perfume from vinegar. Actually, smells or odours are simply mixtures of four basic odours i.e. fragrant, acid, rancid (cheesy), and burnt. Similarly, tastes are combinations of four basic tastes i.e. sweet, sour, salt, and bitter. These tastes are sensed by "taste buds" on our tongue, with the taste buds being clumped together in a pattern on the tongue.

Finally, we should meet another sense, the kinaesthetic sense. This sense tells us where the parts of our body are and involves balance. Receptors in our muscles join with our sight and the semicircular canals in our ears to inform the brain of the location of the body.

In all these ways, the brain is constantly being informed about our environment. It is not surprising to know that other living things also respond to stimuli. For instance, plants will respond to light and water, and even invertebrates will respond to light or touch.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   instruments (line 3), limitations (line 4), approximate (line 5), odours (line 9), combinations (line 11), clumped (line 13), location (line 17), respond (line 20), invertebrates (line 21).
2. What information does the brain receive from different receptors? Electrical impulses
3. What does the kinaesthetic sense (line 14) tell us? Where our body parts are with respect to each other.
4. How many "basic odours" are there? Line 10
5. What are the "basic tastes"? Lines 11, 12

RESEARCH QUESTIONS And whoops! again

6. Who was Hertz? Why was the Hertz named after him?
7. How does the range of human hearing vary as you get older? The upper range is progressively lost
8. Which parts of the tongue can taste
   (i) sweetness,
   (ii) sourness,
   (iii) saltiness, and
   (iv) bitterness?

A standard proc.

Heinrich Hertz (1857-1894) carried out basic work on e.m. waves, being the first to detect them. It was for this reason that the hertz (Hz) was named after him.

See also exercises 99, 103.

★

"CO-ORDINATION - PUTTING IT ALL TOGETHER" 100

Our bodies are organised or co-ordinated by two connected systems. The two systems are called:-

(i) the "nervous system" and
(ii) the "hormonal system",

and are linked together by the brain.

The nervous system is the normal system of senses. In this, a stimulus (for example, a noise) is detected by the receptor or sense organ (in this case, the ear). The noise is turned into a nervous impulse or electrical message which travels to the brain along the auditory nerve. A similar system works for all the other senses, with the brain continually being informed about the outside world. It is the brain, too, that controls our muscles or effectors, causing them to move by electrical impulses. This nervous system is a conscious one.

The hormonal system is less obvious and is in fact not a conscious system. That is, we do not have to think about it for it to work. The brain controls the parts of our body called "glands", and under the control of the brain these glands can give out (or secrete) certain chemicals. These chemicals (or "hormones") are carried around the body by the blood stream to where they are needed. For example, the pituitary gland gives out hormones to cause the start of puberty or adolescence.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

This is a useful way of asking our traditional question! when the students are of lower ability.

1. Find and write down a word underlined which means the same as the following:
   (a) muscles, (b) organised, (c) sense organ, (d) give out, (e) chemicals from glands, (f) able to be thought about, (g) adolescence.

2. Which system works fastest, the nervous system or the hormonal system? Nervous

3. What part of our body controls these systems?

The brain : a sufficient answer at this level.

See also exercises 48, 91.

★

MACHINE MEASURES MOSQUITO REPELLENTS 101

Scientists in Vancouver have developed an unusual machine. This machine functions as an 'artificial host' which attracts mosquitos. This eliminates the need for volunteers, to test the effectiveness of mosquito repellents. Previously these volunteers had to put the repellent being tested on their arms and then expose their arms to swarms of mosquitoes.

The new machine not only saves the volunteers this discomfort. It is also more accurate. Unlike human response, the machine can measure the *exact* amount of chemical repellent vapour needed to cancel out the attraction.

The best repellents are effective at concentrations as low as one part in a thousand million parts of air. This shows that insects are more sensitive than the most delicate instruments now in use.

It is hoped that the information gained through the new 'artificial host' machine will help scientists understand the chemical basis of the repellent effect. This might lead to repellent sprays and creams that are non-greasy and pleasant to use. Eventually it might even lead to a systemic repellent. This could be a 'pill' that would make the user mosquito proof for hours or even days.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article?
functions (line 2), eliminates (line 3), repellents (line 4), response (line 8), systemic (line 18).

2. What is the purpose of the new machine?
See lines 2-6

3. What are the advantages of the new machine over human volunteers? More exact, less unpleasant

A "food source" which has been made by human artifice. Samuel Pepys was full of praise when he said of something: "it is artificial". How words change!

4. What do you understand by the concept of an "artificial host" (line 2)?

RESEARCH QUESTIONS

5. Find out why mosquitoes (or other insects) are so sensitive to very small amounts of chemicals.

One comment which we elicited ran like this:

"Smallness reduces the distance over which conduction of impulses is required, and compels a reduction in the number of neurones possible in the nervous system, producing an economy of cells where the stimulation of a single sense cell may be adequate to set off chain behaviour."

So now you know.

See also exercises 37, 103.

★★★

BATS STILL USE THEIR EYES 102

In at least two species of bat *Carollia perspicillata* and *Phyllostomus hastatus* vision plays an important part in the avoidance of obstacles. Experiments were carried out on these bats in outdoor cages in Trinidad. The animals had to fly the length of the cages (4.9 metres) passing between vertical strips of white cloth. The 300mm. wide cloth strips were hung across the middle of the cage, with gaps between them 70 - 100mm wider than the bats' wing-span. All the experiments were carried out in subdued daylight.

After about 50 such flights, the bats were then blindfolded (with aluminium or black polythene masks) or deafened (temporarily with cotton wool plugs) or both. They were then allowed to fly through the obstacles again.

The normal bats were well able to avoid the obstacles. Blindfolding these bats had little effect on this ability, whereas deafening them impaired their performance considerably. However, bats which were deafened and blindfolded were much less able to avoid the obstacles. The deafened bats showed no changes in their avoidance noises as they approached the cloth strips. The normal and just blindfolded ones, however, increased their pulse repetition rate when approaching the barrier.

The bats could thus see the cloth and could, to a large extent, avoid the strips using sight alone. While the acute sense of hearing used in echo location is still the most important factor in the avoidance of obstacles by bats, this passive visual surveillance system is a useful second line of defence. This is especially so in species which rest during the day and are exposed to predators. Also, as acoustic orientation is effective over only small distances, echo location would not detect a distant navigational cue or obstacle even if it was as large as a mountain.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article?

   subdued (line 8), impaired (line 13), acute (line 20) factor (line 21), passive (line 22), surveillance (line 22), predators (line 24), acoustic (line 24).

2. Explain the meaning of the phrases:
   (a) avoidance noises (line 16)
   (b) pulse repetition rate (line 18)
   (c) passive visual surveillance system (line 22)

3. What was the purpose of the experiments described in the article? Implied in line 2: to see what part vision plays.

4. List the experimental factors (i.e. the different conditions under which the bats flew) used in the experiment. Could any of these group of bats be considered a *control* group? Which one? See lines 9-11 and below.

5. List in *decreasing* order of ability to avoid obstacles, the various groups of bats used in the experiment.
   Normal, blindfolded, deafened, blindfolded + deafened.

6. From these results write a conclusion which summarises the observations. Be reasonable in your expectations.

RESEARCH QUESTIONS

7. There are other ways by which animals navigate. See if you can find four other methods and mention the animal(s) which use the methods.

4. The control group could vary, depending on the analysts. The "normals" could be "it", but the deafened+unblindfolded group could be a control for the deafened + blindfolded group. When variables multiply, controls become more complex.

7. The sun's position or its polarization in bees, landmarks for many animals; magnetic field in some birds; smells in birds, fish and eels; star positions in some birds, electrical fields in some fish

See also exercises 33, 102 and 104.

★★

INSECT BRAINS 103a

Why do we say "as mad as a hornet" or "as busy as an ant"? It is because these creatures, like other insects, are stimulus bound. They do not examine the whole environment and then "decide" what to do by computing a large number of facts together. They simply respond to a stimulus.

The brain of a blowfly has a mass of 0.84 milligrams and contains about 100 000 cells. It is just under 1 600 microns across (one micron is 10^{-6} metre). Thus it is enormous compared with the brain of a midge, which may be only 200 microns across. The smallest brain of all is probably that of the African ant *Oligomyrmex* which is 150 microns across and contains about 1 000 cells. The EEG from such brains is quite unlike that of vertebrates. No one knows if they sleep or even whether they feel pain. They pay no heed to surgery, but dislike electric shocks and insect repellents. How do such tiny brains work?

The blowfly, for instance, searches for sugar with its chemoreceptors quite regardless of the state of its metabolism. In other words, it does not ask whether it is hungry. As soon as it spots sugar, it wolfs it.

The insect brain achieves remarkable results with very few cells, because it sacrifices detail to speed. The phalenid moths, which are hunted by bats with their sound ranging equipment, evade their pursuers quite well with the aid of only two receptors which discriminate intensity but ignore pitch. A moth pursued by a bat goes into a spiral manoeuvre, in no particular direction. It is more urgent to get out of the bat's path quickly than to hang around wondering which way is best to go.

Even more odd, insects are to a considerable extent segmented not only in their soft tissues but also in their nervous system, so that their bodies can act without their heads. A decapitated fly will clean a piece of dust from its leg or wing while the head will continue to feed for a while. In some insects the isolated abdomen is capable of laying eggs. This is fortunate in such insects as the praying mantis where the female bites the head off the male during courtship. This removes the central inhibition and the male is able to co-operate actively during copulation.

Do your students know of the convention that "Latin" names are printed in italics and underlined in type and manuscript?

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in this article? stimulus (line 2), vertebrates (line 12), metabolism (line 16), discriminate (line 21), intensity (line 21), pitch (line 22), segmented (line 25), decapitated (line 27), copulation (line 32).

2. What do the following phrases mean as used in this article? are stimulus bound (line 2), it wolfs it (line 17), achieves remarkable results (line 18), sacrifices detail to speed (line 19), a spiral manoeuvre (line 22), to a considerable extent (line 25), the central inhibition (lines 31 and 32).

3. Why is the word *decide* (line 3) placed in inverted commas?

3. Because it is anthropomorphic.

4. What enables an insect to achieve remarkable results (line 18) with such a small brain? Explain why.

4. Because they don't "think" - their behaviour is all "hard-wired" in.

5. Explain the meaning of the term chemoreceptor (line 15). Find out 4 other ways in which insects sense their environment

Eyes (light), Antennae (smell & touch), ? (hearing)

6. The passage suggests that a segmented nervous system is important to the praying mantis' way of reproduction. Explain.

Lines 30-32

7. Examine the tone (style of writing) of this article. To what kind of people do you think the author is writing?

7. Is the author writing for other scientists? For entomologists? The intelligent layman? The "man in the street"? Children? How can we tell? How do your students class themselves?

RESEARCH QUESTIONS 103b

8. What is an EEG (line 11)? What does it do? What is it used for?

9. (a) How many microns are there in a centimetre?
   (b) What is the size, in millimetres of the brain, of the African ant *Oligomyrmax*?

10. Using the information in the first sentence of the second paragraph, calculate the approximate mass of one brain cell of a blowfly.

11. Compare the number of cells in the brain of the blowfly and the African ant. Now compare the widths of these two brains. Explain why these are different.

12. Use the library to find the mass of a human brain. How many times heavier is the human brain than that of a blowfly?

8. The electroencephalograph : records neural electric currents. It makes an electroencephalogram, usually a chart of "voltage" variation with time.

9(a) The micron is NOT an SI term, but it may be useful to students to be able to recognise it. 10^{-4}.

(b) 0·15mm.

10. $\frac{8.4 \times 10^{-4}}{10^5}$ g = 8.4×10^{-9} g

11. Volume $\propto$ size^3

12. Normal human brains range in mass from 900 - 1800g. The mean for men is 1400g, and for women is 1250g, but this does not justify "male chauvinism" - see New Scientist 82 (1145) 776-777 (8 March 1979) for details.

See also exercises 99, 100, 103

★★

Think of cane toads with their poison glands, too.

CHEMICAL MESSAGES BETWEEN INSECTS AND OTHER ANIMALS 104

The vocabulary of chemical signals used by insects and other animals to protect themselves is extensive. There is a vast range of chemicals produced that serve for messages. A whip scorpion discharges an acid spray when disturbed. A millipede secretes a poison from its segmentally arranged glands. An arctiid moth emits froth from its cervical glands. These chemical defences of small animals compare with the rather forceful message written in the stench of a skunk's spray.

The chemical secretion, often of very strong odour and discharged in substantial amounts, is stored in glands. As these glands are so variable in number, distribution and structure, there can be no doubt that they have developed independently in the course of evolution. Such animals as millipedes secrete chemicals by oozing them over their body surface. But perhaps the most spectacular insects are those such as cockroaches and earwigs that spray their chemicals, sometimes for several metres.

Most of the chemicals that have been identified belong to a number of common classes such as the acids, aldehydes, ketones, esters, hydrocarbons and phenols. These substances can be accurately aimed at sensitive areas of the face and so irritate predators that they cease the attack and begin vigorous cleansing activities. Mice wipe their eyes and snouts with their front feet; birds ruffle their plumage and rub their heads against the feathers of their bodies; frogs and toads, which are sensitive over their entire body surfaces, scratch affected regions with their feet.

Sometimes these secretions serve another purpose, such as sending out alarms of approaching danger to members of the same species. The ant *Acanthamyops claviger* produces a secretion that serves both for defence and as an alarm signal. Another set of important substances, of course, is produced by animals to exchange messages of courtship and other social activities. These interesting compounds, called *pheromones*, include sex attractants and territorial and trail markers.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article?
   vocabulary (line 1), discharges (line 3), segmentally (line 5), glands (line 5), secretion (line 8), spectacular (line 13), predators (line 19), pheromones (line 30).

2. For what reason(s) do insects use chemical signals?
   See lines 6, 25-31

3. How do these chemical defences actually work?
   See lines 18-20

4. Why do scientists believe that different animal species have developed chemical defence mechanisms independently rather than their being a result of a common ancestor? Lines 9-11
   Joint evolution would probably result in less diversity.

5. What do the chemicals mentioned in lines 17 and 18 (acids, aldehydes, ketones, esters, hydrocarbons and phenols) have in common? All are organic

RESEARCH QUESTION

6. Animals use chemical messages for various reasons such as sex attractants, territorial marks, or trail markers. Name one example of each use (total, three animals). For each of your three examples, describe in detail how the animal uses the chemical.

The Gypsy moth (have you ever heard of "Gyplure"?)
Dogs use urine territorially
Many grazing animals (eg dik-dik) have glands for territorial marking.

★★

BEES 'TAILOR-MADE' FOR POLLINATION 105

Honeybees carry out more than 80% of all pollination done by insects. This means that their pollen preferences are most important. Until recently they would generally avoid lucerne if other food was available. This was because the pollen in lucerne is hard to reach. Yet lucerne crops must be grown, because they yield hay and silage. Dr. Otto Mackensen was aware of this problem. He wondered if he could breed honeybees that would prefer lucerne to other crops.

He knew that certain inherited genes controlled the bees' crop preference. After selectively breeding through five generations of honeybees, Mackensen achieved his aim. To test his honeybees he first chose a place with limited pollen sources other than lucerne. Here, 99% of the bees bred to favour lucerne chose this pollen source. He then took the honeybees to a second location. Here there was a much greater variety of pollen sources. Of the specially bred bees, 54% still chose the lucerne.

Mackensen reported that he might now try to breed honeybees who favoured other particular plants. The pear blossom is another 'problem' plant. Bees will not usually pollinate it if other pollens are available because it has a musty odour. If he succeeds he will have produced a second 'tailor-made' bee.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in the article?

   pollination (line 1), pollen (line 2), silage (line 5), genes (line 8).

2. Why did bees tend to avoid lucerne if other food was available? Line 4

3. Why was it desirable to have greater amounts of lucerne pollinated? Line 5: no pollination → no seed → no new crop.

4. How did Dr. Mackensen determine whether or not his breeding experiments had been successful? Lines 10-14

RESEARCH QUESTIONS

5. What is meant by the phrase selective breeding (line 9)? Explain exactly why this process is used and how it is carried out. What is the origin of the phrase?
   Choosing the best offspring as future progenitors. See ch. 1 of "The Origin of Species"

6. What does the passage mean by the phrase 'tailor-made' bees?
   Selected to do a particular job.

7. Cite at least 2 other examples of selective breeding. State the purpose of each program. What 'starting parents' were used? Why? Rust-resistant wheat, Australian milking zebu, bred for N. Australia, Gamma radiation is used to produce mutant plants for selection.

8. What is another name for lucerne? what countries use this other name? In the U.S.A., it is called alfalfa. The OED says it is called alfalfa in "Spain etc." (sic!). We think it is also used in Switzerland, where Lucerne (lake, canton, city) is/are. The OED says that the origin of "lucerne" as the name for Medicago sativa is unknown.

7. (continued) In general, animals (dogs, horses, cattle) and plants (wheat, fruit trees, flowers, vegetables) have been artificially selected for thousands of years. 71

See also exercises 33, 41, 86, 103

★★

LINK BETWEEN ANTS AND THEIR 'CROPS' 106a

A type of tropical ant whose diet is a fungus that they 'cultivate' themselves is being studied by Dr. Michael M. Martin at the University of Michigan. The fungus cannot survive without the attention of the ants. Martin hopes to find the chemical basis for this association, which is the key to the ants' successful exploitation of their environment.

The ants, called *attines*, inhabit an area extending from Argentina to the southern United States. Each colony serves one queen through a division of labour which is possibly more elaborate than that of bees.

Soldier ants guard the nest while workers of various sizes sometimes cut pieces of leaves from trees hundreds of metres from the nest. The workers carry the pieces back to the nest, where gardener ants cut the leaves even smaller and plant a fungus growth on them.

The ants fertilize the fungus by secreting chemicals on it and remove weeds and other undesirable material from the leaves. Because leaves contain indigestible cellulose, the ants cannot eat them. However, the fungus is effective in decomposing cellulose and converting it into a rich source of nutritive carbohydrates for the ants. By culturing and feeding on such a fungus, the ants have succeeded in utilizing the vast reserves of cellulose material in their environment as a nutrient. Although many insects feed on fungi (fungi grow in the nests of certain beetles and termites), the fungus culturing of the *attines* is believed to be unique.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article?
cultivate (line 1), association (line 5), elaborate (line 9), fertilize (line 14), secreting (line 14), indigestible (line 16), cellulose (line 17), carbohydrates (line 18), culturing (line 18), utilizing (line 19).

2. What do these phrases mean as they are used in the article?
successful exploitation (line 5),
division of labour (line 9),
believed to be unique (lines 22 and 23).

3. List the different types of ants which inhabit each colony. Against each type, write the 'job' each does.

3. Queen, soldiers, workers, gardeners.

4. To what purpose do the ants cultivate the fungus?

4. To use all of the carbohydrate resources available.

5. Why do the ants collect leaves from trees?

5. As "food for the fungus"

6. In the passage, it is stated that the fungus cannot survive without the attention of the ants. What is the role of the ants in keeping the fungus alive? Bringing food for the fungus, but para suggests there is more.

7. Could the ants survive without the fungus? Explain your answer.
Yes, but not necessity

8. What does nutritive (line 18) mean? This word is an adjective. What are some noun and verb forms of this word? What does each one mean? nutriment, nutrition, nutrify, nutrient, malnutrition....

Introduce your students to the dictionary!

9(a) Benefit to one, detriment to other against mutual benefit.

(b) Symbiosis, maybe helotism.

RESEARCH QUESTIONS

106b

9. a) What is the difference between a *parasitic* and a *symbiotic* relationship.
   b) How would you describe the relationship between the ants and the fungus.

10. Why is cellulose an indigestible substance, not only to ants, but to most other animals as well? Most animals lack the necessary enzymes. See notes to exercise 8.

11. Use the library or other resource materials and trace the life cycle of an ant, or a termite. Draw a diagram to summarize your findings and write a page of notes on the life of the insect you have chosen.

A question of over-kill: how would your students know to look under "ENTOMOLOGY"? Will their source mention ants, or Hymenoptera and Formicoidea? "White ants" or termites or Isoptera? You may need to help BOTH your students AND your librarian.

See also exercise 40.

That was what our source said, but he called himself Anton!

★★

BACTERIA 107

Bacteria are very small living things which can be seen only under a powerful microscope. They were first discovered in about 1680 by Anthony van Leeuwenhoek a Dutch draper. His hobby was making small but strong lenses and using them to look at all sorts of things. Some of his lenses were no larger than a tomato pip, but they magnified objects some 200 times.

Leeuwenhoek discovered a whole new world of tiny organisms, many being very important in our lives. Some are useful and some do us harm.

Whoops!

They are in some ways like fungi, in other ways they resemble algae. They are also similar in some ways to one-called animals. They are found in the soil in the air, and in the depths of the oceans. Bacteria cause food to go bad and dead plants and animals to decay. Many diseases of animals and men are caused by bacteria, and so are some diseases in plants.

All bacteria are very small, and consist of one cell only. If you put 4 000 of them side by side they would measure about 1 centimetre, but even then you might not see them, as most bacteria are colourless. They are usually shaped like balls, rods or corkscrews. Sometimes they are linked in a chain, sometimes like a bunch of grapes. Some are quite still, others have little hairs which help them to move around.

Bacteria increase in number just by splitting in two, and if everything is right for them they increase very rapidly. One bacterium may turn into billions in the space of a day and a night. Luckily nature has several ways of keeping their numbers down, otherwise they would soon cover the entire earth.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

2. Small, single-celled. The passage does not mention lack of internal membranes.

1. What do these words mean as they are used in this article? draper (line 3), pip (line 5), magnified (line 5), fungi (line 8), algae (line 8), decay (line 11).

2. List the features common to all bacteria.

3. Where do bacteria live? Ubiquitous

4. What do bacteria do? What would the world be like without them? Break down dead material, as well as cause disease. We'd be knee-deep in dead things.

5. Tch tch! Why not in millimetres, pray? Well it is a two-star passage!

5. What is the size, in centimetres, of one bacterium? 1/4000

RESEARCH QUESTIONS

6. Describe in detail using a diagram, one of van Leeuwenhoek's microscopes. Simple, not compound like Hooke's - just one lens.

7. List 5 ways in which bacteria are
   a) useful to man (decomposing, decomposition, useful biochemicals, nitrogen fixing...
   b) harmful to man.

7(b) Any five diseases will do

8. In what way(s) do bacteria resemble
   a) fungi. decomposers, disease-causing
   b) algae. single-celled, autotrophic (some)
   c) animals. heterotrophic (some), no cell wall.

9. Draw a series of diagrams to show what
   a) individual bacteria look like.
   b) colonies of bacteria look like.

10. Fission. There is no sexual fusion as we usually understand it.

10. How do bacteria multiply? Use reference books to describe this process in more detail.

11. What is meant by the phrase everything is right for them (line 20). What do bacteria require for everything to be right for them?

11. Temperature, pH, food, water, lack of (removal of) waste products.

★★

EARTHWORM'S MOVEMENT SPEEDS 108

Changes in earthworm's speed of movement are interesting. They move approximately 25% faster in the night than in the day. Their rate of movement is also connected to an annual seasonal cycle. The exact difference between the evening and the midday speeds vary from month to month. This difference is greater in August (46.6%) and least in January (17.6%).

Observations showed that there is also a third factor seeming to influence speed. This is a connection with lunar cycles. The worm seems to react more to a full moon than to a new moon.

One suggestion for this variation is that some or all of these cycles occur in response to geophysical stimuli. These stimuli might be quite obvious to the earthworm, but not apparent to humans.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words means as used in the article?

annual (line 3), cycle (line 3), factor (line 7), response (line 11), geophysical (line 10), stimuli (line 10) WHOOPS!

2. When would an earthworm move fastest?

A. A hot August day following a full moon.
(B) A cool August night with a full moon.
C. A January night with a full moon.
D. A January day following a new moon.

temperature is not identified as a factor.

3. What are the three factors which seem to influence earthworm movement? Moon phase, season (day length?), day/night.

RESEARCH QUESTIONS

4. What are geophysical stimuli (line 10). Suggest some stimuli which are geophysical. Gravity, geomagnetism.

5. Using the information in the passage, from what part of the world do you think this research comes? Why?

Europe or Northern Hemisphere - a good class discussion question.

See also exercise 110.

Class Crustacea, Sub-class Cirripedia
Lepas sp. goose barnacle
Balanus sp. acorn barnacle *
Now you can look it up in BEPS*!

★★

BARNACLES 109

The barnacle is a small shellfish which belongs to the group of animals called crustaceans. It has a habit of sticking itself to anything convenient. The famous scientist T.H. Huxley described the barnacle as *"a crustacean fixed by its head and kicking its food into its mouth with its legs."* At low tide you can often see a thick crust made up of millions of barnacles on piers, rocks and breakwaters. They fix themselves on to the bottom of ships too. These have to be scraped from time to time to get rid of them.

In the days of small sailing ships, barnacles were a real danger because they slowed down ships and made steering difficult. Many a whaler could hardly get home after a two year cruise, because of the masses of barnacles clinging to its hull.

There are many different kinds of barnacles. One is the acorn. This prefers to live on a rock rather than on wood or iron. It grows on rocks and does not have the short stem that other kinds have. The goose barnacle was given its name because years ago people used to think that it produced goslings. (One of the black and white geese is called a barnacle goose still.) It chooses floating wood or ships and attaches itself with a long stalk.

When barnacles hatch from their eggs, they look like tiny crabs or lobsters and they can swim about. It is only when they grow older that they find some object to cling to for the rest of their lives. Then they grow a shell and only their six pairs of feathery appendages still move about to reach for their food. Their main diet is usually smaller water creatures.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? shellfish (line 1), crustacean (line 2), whaler (line 11), gosling (line 17), appendages (line 23).

2. What are the differences between an acorn barnacle and goose barnacle? Para. 3: on rock or wood, stemless or stemmed.

3. What sort of barnacle would have attached itself to the bottom of whalers? Goose barnacle

4. What do the tentacles of a barnacle do? legs

whoops!

They really are legs, so we'll change this. Lines 405

RESEARCH QUESTION

5. How does a barnacle attach itself to rocks, or wood or metal? By first antennae, then by cement from cement glands. Stalk of Lepas is a modified head.

6. What is an operculum? What is its function? Door made of shell material. Usually only opens under water.

7. If barnacles are fixed in one spot for all their adult lives, how do they mate? Hermaphrodite with a long reach. BEPS* suggests isolated ones self-fertilise

8. What do barnacles have in common with other crustaceans? Marine (most), filter feeder, early stages look crustacean

9. Collect some information about "goose barnacles" and "barnacle geese". The best source for this information would be a book called a bestiary. What other strange animals were "believed in" in the Middle Ages?

9. The best reference is Gerard's Herbal. In-service Library was asked to purchase a copy in late 1979. Phone (02) 922-6700 or write to P.O. Box 460, North Sydney, 2060. See below exercise 111 for a sample.

See also "Homo Monstrosus" in Scientific American, October 1968, p. 113.

* BEPS: Borradaile, Eastham, Potts & Saunders The Invertebrata (Cambridge U.P.)

See also exercises 109, 112.

SOURCE: Adapted from Simon Dresner : "Coral", Science World, Vol. 17, No. 12, Dec. 6, 1968 pages 12,13.

★★

CORAL

110

When Europeans first explored the South Pacific, they were fascinated by the many coral-fringed islands they found. But the explorers did not realise that these islands are really like the tip of an iceberg - an iceberg made of coral.

It's hard to believe that these masses of stone were built up by tiny blobs of jelly, each no larger than a grain of rice. The animal responsible is called a polyp, and belongs to the same family group as the jellyfish and sea anemone.

The coral polyp is a simple creature - it's merely a tube, closed at one end and with a mouth at the other end. The mouth is surrounded by slender tentacles. The tentacles push food into the mouth; waste products are squirted out the same opening.

The polyps feed upon plankton - a mixture of tiny plants and animals, many of them microscopic, that thrive by the billions in seawater. The coral polyps are carnivorous, choosing only animals such as baby shrimp, young starfish, or crabs.

Skeletal material is continually excreted by the base of the polyp, pushing the polyp upward so that it stays on top of its skeleton. The coral polyp produces carbon dioxide, as do all living animals. This combines with calcium hydroxide that exists in seawater formed from the weathering of limestone rocks on land and under the ocean. Calcium carbonate is formed.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What are the meanings of the following words as they are used in the passage?

   tentacles (line 11), plankton (line 13), carnivorous (line 15).

2. What does the author mean when he says that "these islands are really like the tip of an iceberg" (line 3)? Mostly hidden below water

3. How large is a coral polyp (line 7)? See line 6

4. Corals belong to the Animal Phylum : Coelenterates. Name two other animals belonging to this phylum. Hydra, jellyfish....

5. Why do corals make a skeleton (line 18)? Protection

6. What is the skeletal material composed of (line 17)? Line 21

RESEARCH QUESTIONS

7. Find out how members of the Coelenterate phylum kill their prey. Nematocysts (stinging cells) should be mentioned.

8. Name other sea creatures which use plankton as their food. Baleen whales...

9. Write chemical formulae for the chemical compounds mentioned in the passage. CO_2, $Ca(OH)_2$ $CaCO_3$

10. Write a chemical equation for the formation of calcium carbonate from carbon dioxide and calcium hydroxide.

Polyps: Trembley sent hydras from Holland to the Comte de Réaumur, and the Count was reminded of the cephalopods. A valid name for squids and octopodes is "polypus" - you'll even find it in the Shorter Oxford. It was Réaumur who named them polypes (in French) which led to our polyps.

★★

RECOLONISATION - HOW SUCCESSFUL? 111

What would happen if all small animals and insects in an area were killed? Would they somehow be able to recolonise that area? Two zoologists decided to find out. They selected 6 small, well-spaced islands. Next they placed huge nylon tents over the entire surface of each island. They then sprayed enough methyl bromide under each tent to kill all small animals and insects. The spray did not harm the mangrove trees.

Before fumigation about 28 species of small life lived on each island. Three hundred days after fumigation a check was made. All of the original 28 species had recolonised. However the composition of the various species was much changed. The extinction rate was very high. About every 10 days another species would become extinct.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? recolonise (line 2), zoologist (line 2), fumigation (line 7), composition (line 9), species (line 9), extinct (line 11).
2. What was the purpose of this experiment?
3. How was the animal life on the islands killed?
4. Where did the new individuals for the recolonisation come from?
5. Consider this section of the passage - "all of the original 28 species had recolonised. However the composition of the various species was much changed." Explain how the species can "all recolonise" if the "composition of the species was much changed"?

2. See lines 1 & 2
3. See lines 4-6
4. From the other islands or the mainland

5. This refers to the numbers: presumably 300 days is NOT enough to establish a stable population.

AN EXTRA Q: Why was a species becoming extinct every ten days?

This excerpt relates to exercise 109:

There is a small island in Lancashire wherein are found the broken pieces of old and bruised ships ... and also the trunks and bodies with the branches of old and rotten trees cast up there likewise, whereon is found a certain spume or froth that in time breedith unto certain shells in shape like those of the Muskle, wherein is contained a thing in form like lace of silk ... one end of which is fastened unto the inside of the shell even as fish of Oisters and Muskels are: the other end is made fast unto the belly of a rude masse or lumpe which in time cometh to the shape of a bird; when it is perfectly formed the shell gapeth open and the first thing that appeareth is the aforesaid lace or string; next come the legs of the bird hanging out and as it groweth greater it openeth the shell by degrees, til at length it is all come forth and hangeth onely by the bill: in short space after it cometh to full maturitie and falleth into the sea where it gathereth feathers and groweth to a fowle bigger than a Mallard and less than a goose having blackle legs and bill or beak and feathers blacke and white spotted in such manner as is our magpie ... We conclude and end our present Volume with this Wonder of England. For the which God's name be ever honoured and praised.

See also exercises 100, 110.

★

"BONE AND SKELETON" 112

The skeleton of the body has at least three functions. The skeleton supports the body, helping to keep its shape; parts of the skeleton help to protect vital organs, such as the ribs protecting the lungs and the heart; and the bones allow muscles to operate for movement.

Bone itself is a complicated thing. It is made of both living and non-living material. The living material called bone marrow allows bone to grow and repair itself, while the non-living material gives it strength. Another interesting fact is that the red cells in blood are also produced in the bone marrow.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   supports (line 2), vital (line 3), operate (line 4), material (line 6), produced (line 8).
2. Which part of the skeleton protects the heart and lungs? Ribs
3. Is bone made only of living material? No - lines 5 & 6
4. What is the living material in bone called? Bone marrow
5. Can bones heal? Yes*
6. Where are red cells made? Lines 8 & 9

RESEARCH QUESTIONS

7. Draw a human skeleton and mark in the names of as many bones as possible. You could issue copies of the diagram in Mastery Tests M9 & M10 here!
8. About 1900, "whalebones" were used for many things. Find out what the "whalebones" were, and what they were used for.

An elastic horny substance which grows in a series of ff in parallel plates in the upper jaw of certain whales in place of teeth; baleen (OED)** Used in whip handles, women's stays,† and corsets.

* A good article appeared in Scientific American, October 1965, page 18, which deals with piezo-electric effects induced by stress in knitting bones. It appears that charge differential direct the efforts of bone-forming and dissolving cells.

** We use the "Shorter Oxford" all the time: we don't see how your students can get on without it. But do they know how to use it? And do they know that it is a Good Thing to use one often?

† If your corsets are killing you, does this constitute a stay of execution?

See also exercise 144.

SOURCE: The Australian Museum Leaflet No. 58, June 1967.

★★

THE CRESTED WEEDFISH

113a

The Crested Weedfish resembles, in form and colouring a piece of the kelp amongst which it lives. There are often light flecks on the body or window-like transparent spots on the fin-membranes, simulating holes and tears in the weed. The fish is therefore camouflaged so that it is hidden from its enemies (other fishes which eat it) and can approach its prey without being seen. It is a weak swimmer and "walks" along on its finger-like ventral fins, aided by the side (or pectoral) fins, as it stalks the crustaceans, worms and small fishes on which it feeds. It is sometimes hooked on a bait of conjevoi, prawn or fish.

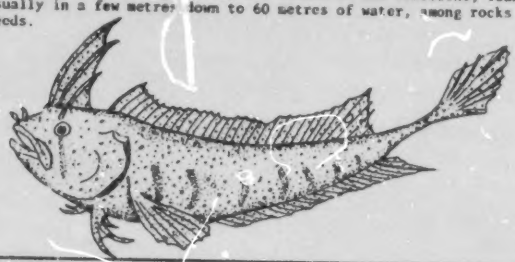
There are several Australian species of Crested Weedfishes in the genera *Cristiceps*, *Petraites* and *Clinus*. They belong to one of the Blenny families (family Clinidae), and are known as Klipfishes in South Africa, where some grow to nearly 0.6 metres in length, and are good eating.

In *Cristiceps* the front dorsal fin forms a crest of three spines on top of the head. In Victoria this fish is known as the "Policeman".

Most of the Australian Crested Weedfishes are only a few centimetres long, but a few reach 15 cm or more. *C. australis* attains 23 cm, *C. aurantiacus* 25 cm and the broad-headed *Petraites johnstoni* 35 cm.

The Crested Weedfish is viviparous. The eggs are fertilized in the female's body and very numerous larval fishes are produced alive. One female *Cristiceps aurantiacus* had about 2170 embryos in her uteri, each one with the tail curled round and the head and eyes resting above the curl of the tail.

The Crested Weedfish's colour is usually brown or greenish, with light and dark markings and often with a dark-brown bar reaching below each eye, but the colouring can be changed to harmonize with the fish's surroundings. They are fishes of the shoreline, found usually in a few metres down to 60 metres of water, among rocks and weeds.



DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

113b

1. What do the following words mean, as used in this article?

   kelp (line 2), simulating (line 4), stalks (line 9), crustaceans (line 9), cunjevoi (line 10), larval (line 24), embryos (line 25), harmonize (line 3)).

2. The words genera (line 13) and uteri (line 26) are both plural. What is the singular for these words? What do they mean? genus, uterus

3. (a) In what way is the Crested Weedfish camouflaged? Lines 1-4, 28-31.

   (b) Of what benefit is this camouflage to the fish? Lines 5-7.

4. What is the meaning of the word viviparous (line 23)? How is the crested weedfish different in this regard from most other fishes? young born alive - not common in fish

5. What do you think *C.* stands for in *C. australis* (line 21) and *C. aurantiacus* (line 22)? Cristiceps. Students should know this usage.

6. The diagram shows an adult specimen of *Cristiceps aurantiacus*. This diagram is about

   A. one quarter the size of the fish.
   (B.) half the size of the fish.
   C. the same size as the fish.
   D. twice the size of the fish.

   NB! This representation is SMALLER than the student copy.

7. Make a neat copy of the diagram. On this diagram label the *ventral fins*, *pectoral fins*, and the *front dorsal fin*.

8. Next to your diagram draw a small scale showing the size of the weedfish.

9. Using information in the article use appropriate coloured pencils to colour in your diagram.

A "print master" copy appears on page 137 of this manual.

RESEARCH QUESTION

10. Why is the crested weedfish known as "Policeman" in Victoria?

Sorry! We don't know.

See exercise 36 for details of this series.

Axolotls will be known to some of your students as "walking fish" - they are sold under this name.

AXOLOTL HEADS TRANSPLANTED ★★★ 114

In the past scientists have experimented with transplanting the head of a young dog to the body of another living dog. These attempts have failed. Either the head has not functioned on the host dog has died. With axolotls it has been different. The heads of axolotl larvae have been transplanted on to older axolotls. Not only have some of these second heads survived *in situ* but they have also showed signs of movement and function afterwards. This is probably because the axolotl can regenerate many different tissues, even brain tissue.

One experiment involved 49 grafts of heads from larvae 1.6 to 1.7cm long on to older animals of 6 to 8cm. Thirteen of the grafts remained attached to their hosts. The rest dropped off after 2-3 days. Immediately after transplantation the heads became pale. Two days later they reddened, showing circulation was restored. About nine days after the operation the second heads looked normal and began to grow. The growth rate of these second heads was faster than that of the original heads. This implies that separate mechanisms controlled the growth rates of the two heads even though the body supplied the same growth hormones to both heads. In a few cases the transplanted head eventually grew as large as the host head.

One of the female hosts was so little worried by the transplant that she mated and produced offspring. Six of the successful grafts also showed movement. To encourage this movement the heads were stimulated. In response to this they opened their mouths and drew in their eyes. Apart from these simple responses, however, they could do little. When, for example, the host head was feeding, the transplanted head did not move at all.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article?

   regenerate (line 8), grafts (line 9), mechanisms (line 16), hormones (line 18), offspring (line 21), stimulated (line 23), responses (line 24).

2. What is the meaning of *in situ* (line 6)?

2. in position, in place

3. Why have axolotl transplants been more successful than dog transplants?

3. Lines 7 to 8

What evidence do scientists have to suggest that the transplanted heads and the host heads are controlled by separate mechanisms?

4. Lines 15-16, 24-26

5. Redraw and complete the following table:-

Total Number of grafts	Unsuccessful grafts	Showing Responses	Not Showing Responses

RESEARCH QUESTIONS

6. What are axolotl larvae (lines 4 & 5)? Find out more about the life cycle of the axolotl. Write a page of notes, including a diagram of the life cycle.

6. Young axolotls

7. Regeneration (line 8), is a process which quite a few animals can carry out. Find out
   a) in general, what sort of animals can regenerate in the way suggested in the passage.
   b) five other animals which can regenerate like axolotls.

7. Starfish (seastars), lizards, flatworms, crabs, lobsters.

8. There have been in Australia, at least two disastrous ecological situations arising because of the regenerative abilities of animals. Find out more about these (Hint: Great Barrier Reef, oyster farming in Newcastle).

8. Starfish

9. Why would scientists want to conduct such bizarre experiments as these? Are they justified? Are they cruel?

9. To learn how growth is controlled.

We set out to show that we, too, can use verse. Have we failed?

★★

ODE TO THE CAMEL 115

The fat in the hump of a camel is not metabolically wet,
For the water it loses respiring is greater than it could thus get.
The wool(or fur) of these beasties protect their innards from heat;
The eyes are soon hidden from sandstorms - and consider the size of
their feet.
It's truly an interesting mammal; its temperature soars in the sun
To full forty degrees before sweating - I doubt if that's very much fun.
The kidney of all dromedaries can concentrate urine and salt;
They can lose over a third of their fluid before they are brought to a halt.
But the rate which they swallow down water, if water they happen to find,
Is up to twelve litres a minute, which leaves us a long way behind.
When staying alive without water, the camel is certainly boss.
They don't have to drink water in winter, enough is dry fodder and dates,
So why call them the *'ships of the desert'*, those odd, even-toed ungulates?

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this poem?
metabolically (line 1), respiring (line 2), innards (line 3), dromedaries (line 8), concentrate (line 8), fodder (line 13), ungulates (line 14).

2. Why do you think camels are called the *ships of the desert* (line 14)? Used to "navigate" the desert.

3. What does the poet mean by the first two lines of this poem?
It does not represent an available water resource

4. What one characteristic of mammals mentioned in this poem leads you to the conclusion that the camel is a mammal?
"The wool (or fur)" (line 3)

5. List *four* characteristics of camels mentioned in the poem which suggest that camels are well suited to the environment in which they live? hair, eyes, feet, water relations

6. There *seems* to be a contradiction in the expression "odd, even-toed ungulates" (line 14). Explain this *apparent* contradiction.
odd = unusual even-toed = even number of toes

RESEARCH QUESTIONS

7. The camel mentioned in this poem is the dromedary. There is another type of camel known as the Bactrian camel. What are the differences between these two types? Hump

8. It has been said that there are more camels in Australia than in Africa. How did this come about? They have been let loose and not cropped (until now).

Try some yourself: "A wish to comply", Robert Frost; "When I heard the learn'd astronomer", Walt Whitman; "Cosmic Ball", John Updike; "Under Which Lyre", W. H. Auden; "Synthetic Such", Robert Graves; "The Fish", Rupert Brooke; or find some of your own.

See also exercise 117.

The roll of the immortals (or were they?)

Petri and his dish
Bunsen " - burner
Kipps - - generator
Fehling - - solutions
Simpson - - rule
Rorschach - - test
Wheatstone - - bridge
Wimshurst - - machine
Millikan - - oil-drop
Van de Graaff - - generator
Liebig - - condenser
Whistler - - mother
Middleton - - reagent
Schiff - - fixative

★★

SEEDS GERMINATE AFTER 500 YEARS — 116a

Germination of seeds estimated to be 500 years old has taken place. Scientists were given the seeds by archaeologists. The seeds were part of a necklace made of *Juglans australis* nuts. The necklace came from an ancient tomb which has just been excavated. Inside each of the nuts was a seed of *Canna*. Carbon-14 analysis of some animal bones also found at the excavation site dates the seeds at around A.D. 1420.

To see if the seeds would germinate, scientists placed one seed on moist filter paper. This was placed inside a Petri dish covered with polyethylene. The glass was kept in the dark at a temperature of 27°C. After a few days a rhizome appeared and grew to about 2mm long. Growth then ceased. Fertilizers were added but had no effect.

A second *Canna* seed was sown in sterile conditions in a highly nutritious medium. Two fresh control seeds were also placed in this medium. The darkness and 27°C temperature control were again set up. After 3 days scientists found that all three seeds had germinated. Rhizomes sprouted first, then roots and finally, leaves appeared. The plants were gradually exposed to light to permit photosynthesis and were then transferred to an environment of 21°C.

By the tenth day the ancient seed had a leaf which measured 3.3cm but which was still tubular. It had a good root system. The only apparent abnormality was some disturbance in its geotropism. The second control plant at this time had a 1.5cm leaf. The plants were later planted in gravel and kept in a greenhouse where they continued to grow and develop. Although the leaves of the ancient plant and the control plant differed this may not be due to the age factor. It may have been caused by a difference in the variety of the old and new seeds.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article? germination (line 1), archaeologists (line 2), sterile (line 14), nutritious (line 15), photosynthesis (line 20), tubular (line 23), abnormality (line 24).

This question will be too difficult for most students - class discussion may be a good idea.

2. a) What is control (line 15)?
   b) Why is a control used in an experiment?
   c) What control(s) are used in these experiments?

3. Draw neat, well-labelled diagrams to show how the ancient seeds were 'set up' in the experiment described in paragraph 3.

4. After successful germination and growth occurred, several differences were noticed between the ancient seed plant and the control seed plant. List these differences. Why did they occur? Low geotropism, leaf longer.

116b

5. What is rhizome (line 18)? What is its function? Where would you expect to find it? Draw a diagram to show what a rhizome looks like. *Underground stem*

6. Why were the seeds placed in the dark (paragraph 2)? Do plants need light to grow?

RESEARCH QUESTIONS

7. What is geotropism (line 25)? Design an experiment which attempts to show that geotropism does occur.

8. How does Carbon-14 analysis work (line 6)? How do scientists use C_{14} analysis to determine the age of a specimen? How accurately can scientists measure age this way? Explain your answer.

9. How can the dating of animal bones by C_{14} methods give the age of a plant seed?

7. The ASEP unit on "Senses" has a good experiment: place radish seedlings in water agar (1.5 g agar in 100 mL water). Place dishes on side, rotate 90° every day or two.

8. The half-life of C_{14} is >5000 yrs. PROVIDED we can assume a steady rate of production of C_{14}, then we can "date" material to the time when it was "fixed". In point of fact, bristle-cone pine studies show small systematic shifts, but the principle is good.

9. Bones and seed are assumed to be laid down at the same time.

Footnote: Willard Libby, who received a Nobel Prize for inventing carbon-dating, died in September 1980.

See also exercise 116

★★

CARNIVOROUS PLANTS 117

All animals depend on plants for food. Herbivores depend on plants directly. Carnivores, by preying on herbivores, depend on plants indirectly. However, this dependence is occasionally reversed.

In all, there are about 450 species of carnivorous plants. These depend on animals for their primary source of protein. Some fungi are also carnivorous. Plants usually prey on insects, but some "eat" small birds and mice. Fungi tend to prey on microscopic animals like the eelworms. No known plant preys on larger animals. However, there are stories of a man-eating plant in Africa. However, no scientific evidence of its existence has been found.

It is not known why plants obtain their nutriment this way. However, it is significant that many live in marshy ground. This tends to be very acidic in nature and lacks ammonium salts and nitrates. It is these chemicals that plants usually use a source of nitrogen. It is thought that carnivorous plants also obtain potassium and phosphorus from their animal prey.

The evolution of these plants is almost completely unknown. A species of *Utricularia*, the bladderwort, has been found in Tertiary rocks, but little else has been found as fossils.

It is a mystery how their complex organs of capture evolved. Many biologists suggest they arose by accident and that the benefit of having them gave a selective advantage to the plants having them.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? herbivores (line 1), carnivores (line 2), dependence (line 3), primary (line 5), prey (line 6), nutriment (line 11), complex (line 19), evolved (line 19), arose (line 20).
2. Why do carnivorous plants "eat" animals? Lines 14 & 15
3. What is scientific evidence (line 9)? Why do scientists like to have scientific evidence to support their findings?
4. Why is the evolution of the plants almost completely unknown? Lack of fossil evidence

3. In this context, reputable and supported by specimens. A good discussion point. See also ex. 35, at about line 30.

RESEARCH QUESTIONS

5. Find out the names of five different carnivorous plants. Draw and describe one of these.
6. Australia has many carnivorous plants. Why?
7. The last peragraph of the article seems to imply inheritance of accidentally acquired characteristics. Does this suggestion have a place in theories of genetics or evolution? Explain why.
8. What is meant by the phrase selective advantage (line 21). What is the origin of this term?

5. Venus' fly trap, (Dionaea) bladderwort, (Aldrovanda) sundew (Drosera sp.) Pitcher plant (Nepenthes) " " (Sarracenia)

6. Many soils here are deficient in N & P. We have most of the Droseras.

7. The "Lamarckian" (the term is grossly unfair to Lamarck) view is one of acquisitions imposed by the environment being passed on. The passage refers (presumably) to acquisitions imposed by accidents in the transmission of hereditary information.

8. We presume Darwin is the source - maybe in chapter 10 of "The Origin of Species"? (See the intro to exercise 31).

See also exercises 27, 50, 51, 52, 125.

SOURCE: Life Science Library - The Scientist ★★★

EARTH SCIENCES 118

Earth Science is a relatively new area of study. Most of its branches sprang into existence almost simultaneously at the beginning of the nineteenth century. Such branches include geophysics, stratigraphy, historical geology, palaeontology, geomorphology, petrology and physical geology. Before this specialization, however, several of man's ancient activities had led to some knowledge of the earth. The most fruitful were geodesy (measurements of the earth's size and shape) and mineralogy. Astronomy, cosmology and meteorology also contributed to our knowledge of the earth from early days.

The surge of activity at the close of the eighteenth century was inspired by a raging controversy over the age of the earth. This was fuelled by religious factors. Fossil remains being discovered around the world called into question the Biblical account of ancient history. The fossils indicated that the earth was far older than anyone had thought. Free of old ideas, men began to investigate the earth scientifically for the first time. The earth sciences split and split again. Separate branches to study the oceans, land waters, and the composition of the earth were formed.

Partly because of the late start, knowledge about the earth is still relatively small and controversial. All the data so far collected, for example, cannot explain the earth's origin. Astronomers may still solve this problem before the earth scientists do so.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage. fruitful (line 7), contributed (line 9), fossil (line 12), composition (line 17). Whoops! These will be understood.
2. What caused the upsurge of interest in Earth Sciences in the early 1800s? Interest in the age of the Earth, but also such things as canal building and world exploration.
3. Why is our knowledge of the earth so small, (especially when compared with other branches of science)? We can only scratch the surface (literally).
4. What event or events most probably stimulated the controversy about the age of the earth? This is not a proper comprehension question. It aims at the involvement of the student with the subject.

RESEARCH QUESTIONS

5. What is meant by the phrase "investigate the earth scientifically"? Systematic search for patterns and/or causes? Explain the difference between scientific and unscientific investigations. List several in each category. Try that for a start
6. Find out what each of the branches of earth science (underlined in lines 3, 4 & 5) study. Find 3 others not mentioned in the passage.
7. Geodesy (line 7), is the study of the earth's size and shape. Write about 1 page on the methods used by ancient earth scientists in the study of geodesy. Eratosthenes again!
8. How could astronomy, cosmology and meteorology (line 8), contribute to the knowledge of the earth in early days? Do they still contribute? If so, how?

8. Angelo may fear to tread, but here we go:

Astronomy showed the world was round (see ex 12).

Cosmology: see exercise 125 on transits of Venus (or is this still astronomy?)

Meteorology: the observed Coriolis effect in the atmosphere.

See also exercises 33, 39.

★★★

Note the spelling: cf passage 118, line 4, where we corrected it.

FOSSIL 'GOLDMINE' FOUND IN AUSTRALIA 119a

CANBERRA: Remnants of abundant animal life which roamed the edges of great lakes in a verdant central Australia 26 million years ago have been unearthed by two Commonwealth scientists. Their find: a Tertiary deposit (they have named the Camfield Beds) near the Roper and Victoria rivers in north central Northern Territory. It has been described by Australian paleontologists as a "goldmine". It consists of light coloured calcareous sandstone, siltstone and limestone. A coarse lime cemented conglomerate at the base contains clasts of duricrust and pre-Tertiary rocks.

The unit unconformably overlies Antrim Plateau Volcanics (early Cambrian) and Montejinni Limestone (early Middle Cambrian) and is estimated to have a total thickness of more than 20 metres. Fossil vertebrate remains are scattered throughout the upper half of the exposed section. Drs. M. Plane and C.G. Gatehouse of the Commonwealth Bureau of Mineral Resources, who discovered the beds, report fossils of fresh water molluscs, remains of predecessors of the lungfish found today in Queensland and teeth from prehistoric relatives of the crocodile. The site has also yielded remains of giant ground birds, heavier and thicker set relatives of the emu and cassowary. The biggest 'nugget' is a collection of marsupial remains including representatives of the *Diprotodon* and *Thylacoleo* families.

Plane and Gatehouse say they have found remains of a larger and more morphologically advanced version of the *Diprotodon* than that found in the Lake Eyre Basin in northern South Australia and believe it to be of the middle to late Miocene. The *Thylacoleo* - marsupial lion about the size of a large dog - remains were at the time of writing being prepared for description.

This new fauna forms a link in the Australian Tertiary vertebrate evolution and, together with the Lake Eyre sequence and Alcoota and Riversleigh (north western Queensland) faunas, provides a basis for correlating mammal bearing Tertiary sediments in central and northern Australia.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article?

   remnants (line 1), verdant (line 2), paleontologists (line 6), calcareous (line 6), unconformably (line 9), predecessors (line 15), cassowary (line 18), nugget (line 18), morphologically (line 21).

2. List the various animals mentioned in the recent fossil find.

3. Fossil remains of a marsupial lion have been found in two places. Name them.

4. What is the geological (or biological) importance of this find?

5. What is the meaning of the term unconformably overlies (line 9)? Explain, with the aid of a diagram what this might look like?

6. The article mentions a "goldmine" (line 6) and a 'nugget' (line 18). Why? valuable material.

7. Explain the difference in appearance and composition of the four sedimentary rocks mentioned in the article.

2. Molluscs, fish, reptiles, ground birds, Diprotodon, Thylacoleo, but NOT lungfish, crocodile, emu, cassowary, lion or dog.

3. Camfield beds and (by elimination) Queensland.

4. Samples from new points on the evolutionary line, allows beds of similar ages to be compared & equated.

7. Sandstone, siltstone, limestone, conglomerate.

RESEARCH QUESTIONS 119b

8. What is a clast of duricrust (line 8)? Explain how it forms.

9. How old are pre-Tertiary rocks (line 8)? What does the term Tertiary mean? What does it refer to?

10. What is a *Diprotodon*? Draw one and name a present-day animal to which it is related.

Large proto-wombat, eowombat or ur-wombat, depending on your orientation. See "Web of Life" ch. 13.

See also exercise 9.

★★

CHANGING COASTLINES 120

One of the main factors at work in changing our coastline is wave action. As a wave approaches the coast and breaks, it stirs up sand from the bottom. This happens all the time, but particularly in rough weather.

Most wave action is influenced by the tides. The waves interact with the tidal currents. The tidal currents often run parallel to the coast and cause the waves to move slightly sideways. The direction of the sideways movement depends the direction of the tide. If the tide is coming in, the sand moves one way. If the tide is going out, the sand moves the opposite way: the sand moves back and forth with the changing tide.

However, either the flowing tide or the ebb tide is usually stronger. This results in an overall movement of sand in the direction of the stronger tide.

In this way, a vast amount of sand can be shifted each day. In abnormal weather, a beach may even be completely eroded away overnight.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in this article? factors (line 1), wave (line 1), tides (line 4), currents (line 5), ebb (line 11), vast (line 14), abnormal (line 15).

2. Why do waves often break at an angle, rather than straight on? Tidal effects (but also incomplete refraction!)

3. What is a) a flowing tide (line 11) rising
b) an ebb tide (line 11)? falling

Do your students know this use of "net"?

4. Why is there a net *movement* of sand in one direction along the beach? Sand moves both ways, but more one way than the other

RESEARCH QUESTIONS

5. How are ocean waves formed? Wind action

6. What effect do the sun and the moon have on the world's oceans? Tides - if you want more detail, say so!

7. Why do beaches build up in summer and erode away in winter? We seem to think it relates to wave form & / or length

8. What can man do to stop the shifting of sand
(a) below the waterline? Build a groyne
(b) above the waterline i.e. on the beach? Plant grass etc.

9. Man's activities have caused changes in the coastline. Describe one change that has resulted in erosion of the coastline. How can this be corrected?

Cause: building too close to the beach, driving over dunes. Wind-flow changes, dead vegetation cannot prevent blowouts.

Solution: stop building there, plant grass.

See also exercise 9.

SOURCE: Thayer Willis : "Cape Cod" Science World, Vol. 17, No. 1 Sept. 13, 1968, pages 6,7.

★★

121

CAPE COD

Geologists describe four ways that material is worn away or eroded - by the action of streams, waves, glacial ice, and wind. By far the most important in shaping the shoreline of Cape Cod has been erosion by the waves.

As a wave approaches the shore it runs into shallower water. The crest water at the bottom of the wave is slowed down. The wave becomes steeper and its crest falls forward. The wave collapses into a swirling line of foaming water - a breaker. The mass of water from the breaker surges up the sloping foreshore of the beach.

When a storm wave hits the beach, however, it smashes across the foreshore and strikes a blow at the sandy terrace behind it. Each backwash of the wave carries sand grains back into deeper water.

But waves seldom strike the beach squarely. Usually, they approach at a slight angle. When they do, sand is carried not only up and down the foreshore, but also along the beach. This movement of sand along the shore is important in forming the immense sand bars that jut out at each end of the Cape. A similar movement of sand along the coast occurs offshore in deeper water.

Waves direct their strongest attacks at points and headlands that jut out into the sea. Bays and harbours suffer much less from wave action. Thus the once jagged outline of the Cape was slowly pounded into the smooth curve it is today.

through WHOOPS!

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are listed in the article?
   eroded (line 1), crest (line 7), breaker (line 8), foreshore (line 9), backwash (line 11), sand bars (line 16), headlands (line 19).
2. Name four methods of erosion. Line 2
3. Why does a storm wave reach the sandy terrace behind the foreshore whereas ordinary waves do not. More energy
4. Explain how wave action can move sand grains along a beach. Lines 13-15
5. Why are points and headlands more subject to wave action than bays and harbours? More exposed

---

RESEARCH QUESTIONS

6. Find out why a breaker "breaks". Para. 2 tells part of it.
7. Suggest reasons why waves seldom strike the beach squarely. See passage 120.
8. In many parts of the world, for example, along the N.S.W. coast, points and headlands still exist. Why have these survived while those at Cape Cod have been eroded away? Harder rocks, sea-level variations...
9. Where is Cape Cod? Draw a map of the area.

North Eastern U.S.A.

See also exercise 123.

SOURCE: Life Science Library - Energy ★★★

VOLCANIC ERUPTIONS 122

Less than 64 km beneath the earth's surface are pockets of dense molten rock and gases called magma. This seethes at temperatures up to 1800°C. This molten mass is caused by tremendous subsurface pressures and heat, created by the energetic decay of radioactive substances. Occasionally this magma finds a fissure in the earth's crust and is forced towards the earth's surface. In some areas hot gases from cooling magma heat underground water to such a point that it spouts up in geysers.

Some vulcanologists point to evidence that in the last few thousand million years volcanoes may have produced all the gases in the atmosphere, all the water in the oceans, and much of the land. Only 500 volcanoes are known to have been active in recorded time, but some of their eruptions have dwarfed nuclear blasts.

When Krakatoa exploded in the Pacific in 1883, a mountain vanished, walls cracked 160 km away, tidal waves killed 36 000 people, and the sound was heard 5 000 km away.

Molten lava bursts from Kilauea Iki lasted for 36 days in 1959. Some of the jets of liquid magma being forced from the earth's depths were sent 500 metres into the air. So much lava poured out, that the remaining pool is expected to take 100 years to cool.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in this article?

   dense (line 1), magma (line 2), seethes (line 2), mass (line 3), fissure (line 5), molten (line 16).

2. How have the pockets of magma formed? Lines 3 & 4.

3. What are volcanoes? Where magma comes out: a crack in the Earth's crust

4. What is a geyser (line 7)? Using a diagram, show how a geyser works. Water and mud are forced up by steam.

5. Vulcanologists have made up an hypothesis about the formation of the earth's surface. What is it? Lines 8-10

RESEARCH QUESTIONS

6. Make a list of three other disastrous volcanic eruptions, showing where and when they occurred, and the damage to life and property they caused.

7. What is a thermal region? Thermal regions are often popular tourist attractions. Draw a landscape diagram of a thermal region and label its thermal features.

8. What is radioactive decay? How does "the energetic decay of radioactive substances" melt rocks?

Groundwater comes in contact with rocks at >100°C plus a differential to allow for greater pressure at depths

6. John Butler's Natural Disasters, Heinemann Educational, 1976, lists a number: Vesuvius, Krakatoa, Heimaey, Tristan da Cunha, Mayon and Gunung Agung. Mont Pelée is mentioned, but not named. This book is a useful source of information.
Mount Lamington (PNG), Surtsey (Iceland), La Soufrière (Guadeloupe), Mt. Etna (Sicily), Ngauruhoe (N.Z.)

Our New Scientist volcano file needs updating, but Troy 27 May 1971 on Mt Etna, 26 August 1976 on hazards (432-435). Others have appeared more recently.

See also exercise 122.

This is a good model for teachers who wish to write their own comprehension exercises....

★

VOLCANOES AND MANKIND 123

Man has always been interested in volcanoes. He has seen the might and power of volcanic eruptions and has often seen great loss of life and property because of them. In the early history of man, it was even thought that there were "volcano gods", and many myths and legends grew up around volcanoes. Nowadays, we think of volcanoes as simply lava being forced out of the earth's surface. We think that this lava comes from magma, which is molten rock formed underground.

There are more than 600 active volcanoes in the world, and many thousands which are extinct. The Hawaiian Islands are volcanic and other famous ones include Krakatoa, Etna, and Vesuvius. Australia has no active volcanoes but has had many in the past. Examples of these past volcanoes are the Warrumbungles in N.S.W. and the Glasshouse mountains in Queensland. Many quarries have volcanic rock and there are many dykes along the coast of New South Wales.

It is interesting to find too, that man makes use of volcanoes. He often farms the rich volcanic soils, and uses broken up basalt in the form of "blue metal" on roads. It is also thought that metal ores are igneous in origin, and mineral deposits such as gold, tin and diamonds are produced by igneous activity.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. Explain the meaning of each of the words underlined: eruptions (line 2), molten (line 7), dykes (line 13), basalt (line 15), origin (line 16).
2. What damage can volcanoes cause? lines 2 & 3
3. What are myths and legends (line 4)?
4. What is lava (line 5)? Watch for confusion with larva !
5. What is magma (line 6)? See line 7.
6. How many active volcanoes are there in the world? See line 8
7. Name two useful things that man gets because of igneous activity. Basalt, soil, ores, pumice
8. Does Australia have any active volcanoes? No (line 10)
9. Where are the Warrumbungle Mountains? Near Coonabarabran - it's a great excursion.
10. Name two famous volcanoes. Try line 10

RESEARCH QUESTIONS

11. Find out the origin of the word dyke (line 13). Is it a good word to use?
12. Where is the nearest extinct volcano to you?
13. Find out what a placer deposit is, and how it is formed.

11. This is a case for having access to the REAL O.E.D. - the fourteen-volume version. "Dike" (OED's preferred spelling) can be either a ditch or a wall. As usual, be prepared for sniggers about the slang connotations (Two meanings!). It is a good word to use because the dyke may be weathered below, or stand above, the country rock.
12. Your local geological sheet, or Griffith Taylor's "Sydneyside Scenery" which actually covers much of NSW.
13. Alluvial deposit in valley, lava flow fills valley, old rock erodes, leaving lava hill. This is NOT what is referred to in line 17.

See also exercises 9, 13, 122, 123

SOURCE: How and Why wonder book on Our Earth. ★★

HOW WERE MOUNTAINS FORMED 124

If we were able to slice open a mountain range such as the Blue Mountains, the Rockies, the Andes or the Alps, we would see crumpled, bent and broken layers of rocks. We would also find that many of the rock layers that now tower thousands of metres above sea level were once formed at the bottom of the ocean. We know that this happened because the fossil remains of sea animals have been found in rocks on the topmost peaks.

From these facts, we conclude that the mountains were formed from the rocks of ancient sea floors, and that powerful forces from within the earth broke and folded and raised these rocks into their present positions.

When the mountain ranges rose slowly out of the sea in this way, other forces began at once to go to work. Swift-flowing streams and slow-moving glaciers began wearing the mountains away. This process of wearing the land away by the action of moving water, is called erosion. As soon as the mountains rose above the sea, erosion began to destroy them.

Geologists believe that the surface of the earth is constantly changing in this way - that the earth's crust is in constant motion, like the waves on the surface of a sea. But instead of rising up and levelling off again in seconds, as sea waves do, the movement of the "waves" of the earth's surface is measured in terms of hundreds of millions of years.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? fossil (line 6), glaciers (line 13), erosion (line 14), geologists (line 16), crust (line 17), motion (line 17).

2. What two forces on earth are acting on the rocks in mountains? erosion and uplift

3. What evidence do geologists have that some rocks in mountains were formed under the oceans? Lines 5, 6, 7.

4. In what way(s) do geologists think the earth's crust is like the sea? In what way(s) does it differ?
Moving, but more slowly.

5. In the article, an *analogy* has been used. What is an analogy? Find the analogy which has been used in the article?
Last paragraph. See also exercise 10, questions 10 and 9.5, #142.

6. Why has "waves" (line 19) been placed in inverted commas?

RESEARCH QUESTIONS

7. Water is mentioned as an agent of erosion. There are two others: what are they? Briefly tell how each of the 3 agents wears away rocks. What does "agent" mean here?
That which acts

8. What term does a geologist use to mean "to slice open a mountain range" (line 1)? sectioning.
How does a geologist use such a "slice"
to visualise and idealise.

9. (a) How would you classify the rocks you would see in the "mountain slice"? Give evidence from the passage to support your classification. Sedimentary (line 6)

(b) What would be the classification of the original rocks - the ones formed under the oceans?
igneous.

See also exercises 12, 118, and 34 for notes on the author.

SOURCE: Adapted from "Everything has a history" J.B.S. Haldane, Allen & Unwin (1951) ★

THE EARTH GOES AROUND THE SUN 125

The moon rises slightly later every day compared with the sun. On average, the moon rises and sets each day nearly an hour later. In the same way, the sun lags about four minutes a day relative to the stars. These things can be explained and accurately calculated by a simple idea.

This idea states that the earth and planets move around the sun. According to Kepler's laws, the path of the earth around the sun is an ellipse. But, it has been found that the orbit is not exactly an ellipse, because the earth is attracted to other planets as well as to the sun. Using this information, we can measure the size of the solar system.

For instance, it is quite easy to find out how far away the moon is from the earth. You can photograph it simultaneously against a background of stars in England and South Africa. You can see at once that it has shifted, as a near object changes its position relative to its background if you look at it first with your right eye and then with your left. It is not easy to find out how far the sun is. Occasionally the planet Venus passes directly between the earth and the sun, and can be seen as a black dot. By comparing the time taken by Venus in transit (as this phenomenon is called), as seen from different parts of the earth, the sun's distance was fairly accurately measured in the eighteenth century.

Another measure, not quite so accurate, is the lag of about 16 minutes in the times at which Jupiter's satellites are seen to be eclipsed when the earth is farthest away, compared with when it is nearest. The important point is that these (and other) methods all tell the same story.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage.
   lags (line 3), ellipse (line 7), simultaneously (line 11), transit (line 17), phenomenon (line 18), satellites (line 22).

2. What is meant by the expression "the sun lags ... relative to the stars"? (line 3)

3. Haldane is English, and so named England as one of the two places for moon photography.
   Why would he use South Africa as the other?

3. Same longitude, other hemisphere, well spaced, can take simultaneous photos.

4. By how much does the sun lag in a year? Give your answer in hours. Comment on your results. 24 hours

RESEARCH QUESTIONS

5. (a) Light travels 300 000 kilometres per second. From the last paragraph, calculate the size of the earth's orbit.
   (b) How correct is your answer from part (a)?

288 million km - 300 million km is nearer - 16 3/3 minutes is more correct.

6. (a) How many satellites of Jupiter are there?
   (b) Who discovered the first four satellites of Jupiter? Did he realise what could be done with them?

See article & notes - 12
Galileo. In one sense, yes.

7. (a) What is the *transit of Venus*?
   (b) In Australian history, the study of one transit of Venus has been very important. Why?

Appears to cross the sun's face.
Captain Cook!

8. What are Kepler's laws? Are they still thought to be true?

See any standard text.

9. What does the author mean by the last sentence?

All of the evidence points to the Copernican system.

See also exercises 14 & 15

★★

WILL TRITON CRASH? 126a

Triton is the largest of Neptune's moons. It ranks as one of the giant satellites of the Solar System. Like Jupiter's Ganymede and Saturn's Titan, it has about twice the diameter of Earth's Moon. (The Moon itself has about one quarter the diameter of the Earth.)

Triton is about the same distance from Neptune as the Moon is from the Earth (about 400 000 km). It has an unusual "retrograde" orbit around Neptune and tidal friction is causing it to move closer to the planet. (The Moon, on the other hand, orbits in the same direction as the Earth's spin and is gradually moving away from the Earth.)

In the case of Neptune and Triton, tidal effects are much greater than in the Earth-Moon system. This is due to their larger sizes - Neptune is 19 times more massive than the Earth and four times the diameter. Just as on the Earth, a bulge is raised on the surface of Neptune by the gravitational attraction of its moon. However, the planet's surface is spinning in the opposite direction to Triton's orbital motion. As a result, the bulge cannot "keep up" with Triton and is always somewhat out of line with it. The raised area on Neptune's surface causes a dragging force that contributes to the ever tightening orbit.

If Triton does eventually crash into Neptune, the results are not likely to be as catastrophic as if the Moon crashed into the Earth. Quite likely, Triton will not crash at all, but will break up into pieces when it gets too close to Neptune and end up as a set of rings like those around Saturn.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? satellites (line 2), retrograde (line 7), friction (line 8), tidal (line 12), catastrophic (line 23).

2. Neptune - Triton
Jupiter - Ganymede
Saturn - Titan
Earth - Moon

2. Write down the names of four planets mentioned in this article. Alongside each write down the name of its moon mentioned in the article.

Will your students be worried by subjunctives?

3. If Triton were actually to crash into Neptune, why would the results be less catastrophic than if the Moon crashed into the Earth? (Hint: compare the masses of the planets and their satellites.)

4. What fraction of the Earth's diameter is Triton's diameter?

line 3: watch the Frog!

5. Sketch the Neptune-Triton system, showing the directions of the planet's spin and the moon's orbital motion. Draw the planet and moon approximately to scale, and show the likely position of the tidal bulge on Neptune's surface.

RESEARCH QUESTIONS 126b

6. Find out how many moons are presently known to orbit each planet in the Solar System? See exercise A notes. Pluto DOES have a moon.

7. Find out the names of the four largest 'Galilean' moons of Jupiter. Why are they called the Galilean moons?

8. Are the tidal movements in solid parts of a planet smaller or larger than in the liquid parts of the planet? Give reasons for your answer. Smaller. Less able to surge about.

7. Ganymede, Io, Callisto, Europa.
First reported by Galileo Galilei.

Which planet is furthest from the Sun? Through the 1980s, the answer is NOT what you would expect from the table in exercise 17: Pluto is INSIDE Neptune's orbit. Over to you.

See also exercises 8, 42, 128

Note the date!

★★

SOURCE: Adapted from J.J. Haggerty : "Man's Conquest of Space", Vistas of Science Vol. 12, N.S.T.A., 1966.

127

RE-ENTRY

While an unmanned satellite can be allowed to burn up in the atmosphere when its usefulness has ended, a manned spacecraft must be brought safely back to earth. To do this special devices are needed.

First the spacecraft must be slowed down. In some capsules, small retrorockets located at one end slow the craft. As the retrorockets slow the capsule, the spacecraft drops earthward. Then comes the critical re-entry. Although the capsule has lost some of its orbital velocity, it is still moving at a ? rific rate - 16 000 to 24 000 kilometres an hour. At this speed, contact between the capsule and even very thin air builds up great friction that can destroy the capsule if protection is not provided. This protection is a heat shield, a heavy layer of fibre glass on the bottom of the capsule, which strikes the atmosphere first. Part of the shield is actually melted by the heat of friction and peels off the spacecraft.

After re-entry, the capsule slows more and more from air resistance. It drops to an altitude of about 3 000 metres but is still moving at a few hundred kilometres per hour - much too fast for safe landing. To slow the spacecraft further, a large parachute pops from the top of the capsule. To soften the impact of landing, a large rubber cushion between the heat shield and the cabin inflates like a ba..oon for a gentle "touch down", or "splash down".

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of the following words or terms as used in the passage?

   satellite (line 1), devices (line 3), retrorocket (line 5), orbital velocity (line 7), heat shield (line 11), melted (line 12).

2. Why must some space capsules be brought safely back to earth while some others are allowed to burn up?

3. How do retrorockets slow the spacecraft?

4. How could friction destroy the spacecraft?

5. Why not use the parachute first instead of the retrorockets?

6. What function does the rubber cushion perform?

7. Which slows the spacecraft down the most?
   a) the retrorockets
   b) the parachute
   c) the rubber cushion
   d) the heat shield.

2. Because there are astronauts on board.
3. They fire in a direction opposite to the craft's motion.
4. The heat "created" could melt or burn the craft.
5. No: air must slow down BEFORE reaching air.
6. Soften the blow of landing.

RESEARCH QUESTIONS

8. Why does the heat shield protect the spacecraft?

9. Find out about each of the following manned space research programs: Mercury, Gemini, Soyuz, Apollo. What were the main achievements of each program? When were the flights made?

10. What was the name and nationality of the first person to orbit the earth in space? When did he do this?

8. Non-conductive, refractory, sacrificed.

Yuri Gagarin, Russian, 1961.

See also exercises 8, 42, 127.

SOURCE: Science Journal – about 1968

Whatever happened to this idea ???

★★★

BETTER RUNWAY ARRESTER USES FOAMED PLASTICS 128

The Royal Aircraft Establishment at Farnborough has developed a new system to bring to rest aircraft overshooting a runway.

The new system, claimed to be superior to those presently in use, has been tested at the RAE's airfield at Bedford.

In this system, the material used is a special urea formaldehyde resin developed by BIP Chemicals of the Turner and Newall Group, who have also patented a method of laying a bed by pouring from a hose.

In the test illustrated some five tonnes of foam were laid in the form of two 15 metre long strips. Into these a 16 000 kg test-vehicle, in the form of the major part of a Phantom fighter, was catapulted at more than 130 km/h. The main wheels of the vehicle pulverised the foam and the mean deceleration was approximately 0.6g. Turner and Newall estimate that a 91 metre bed one metre deep would halt "a fully loaded airliner" travelling at 113 km/h, while 300m would stop one travelling at 240 km/h.

An operational bed would be laid across the whole width of the runway overrun area. Once set, the foam can support heavy rescue vehicles, the compressive strength being some 3.5 kg/cm². It is non-inflammable and "can be left for years without maintenance". A particular advantage in comparison to other systems is claimed to be the fact that particles of foam thrown up upon aircraft impact are "so light and soft that they are unlikely to damage the fuselage or engines".

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? resin (line 6), catapulted (line 10), pulverised (line 11) deceleration (line 12), operational (line 15), compressive-strength (line 17), fuselage (line 21).

2. What would be the dimensions (size) of the bed of foam needed to stop a fully laden airliner which was travelling at 240 km/hr? Line 14

3. What advantage(s) does the new plastic foam have over other systems of stopping overshooting aircraft?
Non-flammable, can be driven on, particles are light.

4. What is the mass in tonnes of the test vehicle (line 9)? 16

5. What do the letters RAE (line 4) stand for? Line 1

RESEARCH QUESTIONS

6. What other substances are used to stop aircraft overshooting runways?

7. What is meant by 0.6g (line 12)? Is this a large amount compared with normal gravity?

8. How do scientists research the effect of 'g' force on the human body. Why is this information required? Using a centrifuge

9. Mention 5 other situations when humans are likely to experience 'g' forces. How large are these forces likely to be?
Falling (when you land) braking, accelerating in a car, riding in a lift, turning a corner.

10. Explain how the law of conservation of energy is operating in the process of stopping the overshooting aircraft.
The energy is used to break up the foam bed.

See also exercises 86, 92, 97.

★★

SUGAR SUBSTITUTE PROCESS FROM DENMARK 129a

COPENHAGEN: The Danish inventor Karl Kroyer, who already has to his credit a process for making paper without the use of water, a skid resistant and anti-glare road surfacing material, and a method of raising sunken ships by pumping them full of polystyrene balls, has developed what he hopes will become an important substitute for sugar. The product, which Kroyer calls 'total sugar', is not exactly new - and is, in fact, glucose. However, what Kroyer has done is to develop a new and commercially viable process for producing crystallised glucose from starch products. This crystallised glucose looks very much like ordinary white cane or beet sugar - sucrose.

Although the product is only about three quarters as sweet as sucrose, Kroyer is placing his hopes on the dietary benefits of glucose over sucrose. A good deal of research has by now shown that there is a link between sucrose consumption and cholesterol levels and that the cholesterol level can be reduced by substituting glucose for sucrose. Sucrose is also a much better medium for growing bacteria such as the streptococci which produce dental caries; indeed, Swedish experiments with hamsters have suggested that the incidence of caries could be much reduced by a similar substitution.

Kroyer is currently planning a conference, to be held in October, for the food industry to persuade them to change their recipes in favour of glucose. So far there are only two plants producing total sugar, one in Holland and the other at Ashford, Kent, operated by Hovis-McDougall, and their output is only about a tonne an hour. But the prospects are promising, says Kroyer. The cost of producing total sugar is about the same as producing ordinary sugar, but any starch product can be used as raw material for the process.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of these words or phrases as they are used in the passage?

   commercially viable (line 7), crystallised (line 8), link between (line 12), medium (line 15), caries (line 17), prospects (line 22).

2. What are some of Kroyer's inventions? Lines 2-4

3. According to the article, Kroyer suggests that the food industry should change from using X to using Y. Identify X and Y. sucrose and glucose

4. What is the main production advantage of the Kroyer process? Any starch source will do.

5. Why does Kroyer want the food industry to start using glucose in the place of sucrose? Medical reasons (reduce cholesterol), dental reasons.

6. Why does Kroyer need to persuade the food industry to change from sucrose to glucose - why wouldn't the industry automatically accept his recommendations? *

7. What are dietary benefits (line 11) of glucose? As in Q.5.

8. Why do you think Kroyer called the product 'total sugar'? (line 5). Your guess is as good as ours.

* New technology means new machinery, packaging, supplies of raw materials, marketing strategies.

Watch out for Tollin, Tate and Lyle's (UK) substitute. This is a 20-amino acid polypeptide which they hope to market as a safe substitute.

RESEARCH QUESTIONS 129b

9. What are the chemical differences between glucose, sucrose and starch?
Mention physical, chemical and structural differences.

10. What is the difference between sugar and sucrose?

11. Write a brief summary of the commercial method of obtaining sucrose from sugar cane.

12. What is cholesterol (line 13)? Where would you find cholesterol? What harm is it thought to do to humans?

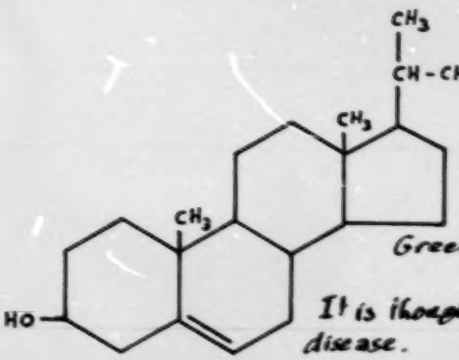
13. Explain the science behind the concept of raising sunken ships using polystyrene balls (line 4).

9. Structural : mono-, di- and polysaccharide.
Physical : mol. wt., b.p., m.p., solubility, size of molecules
Chemical : reactions with enzymes, Fehling's sol'n, "iodine sol'n".

10. Sugar is a generic often used to indicate a specific sugar which is sucrose.

11. Obtainable from CSR, or the Blue Messel, about ch. 5.

12.



A major constituent of gall-stones. The name comes from the Greek for "solid bile".

It is thought to be related to heart disease.

13. The balls are taken down in small groups (or pumped) into the ship. Eventually, their buoyancy is enough to raise the ship.

See also exercises 59, 129.

★★

We saw another use for sheep gut in #59.

130

NEW SAUSAGE SKIN

What are sausage skins made of? Generally sausage skins or casings are made of top quality sheep intestines. These are often hard to get. Pig and beef intestines are then used but not as successfully. They are difficult to stuff with sausage meat and their wall thickness and diameter varies too much.

One company found a way to solve the skin problem. They made casings from collagen which is a fibrous high-protein substance found in animal hides and tendons. To make the collagen skins, beef tendon is cleaned, frozen and finely sliced, forming a fibrous mash. It is then mixed in a gelatin solution. The next step is to force it through a ring-shaped nozzle to make the casing and then into a coagulating bath of ammonium sulfate solution. At this stage the wall thickness of the casing is about 0.04 cm. This decreases to 0.0025 cm after a series of tanning and drying treatments.

The skin is finally cured for 16 hours at 80°C. The result is a thin walled sausage casing. A bonus is that this casing will not burst during cooking.

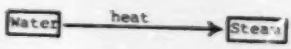
DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   solve (line 6), coagulating (line 11), solution (line 12) cured (line 15).
2. Why was a substitute sausage skin needed? Lines 2 & 3
3. What was the problem with pig and beef intestines? Line 4 & 5

You may wish to relate this question to mastery tests M61 & M62

4. Construct a flow chart of the manufacturing process of collagen sausage skins. (Remember to put your products in the boxes and the processes on the arrows).

   e.g. See below

5. How many times thinner is the finished sausage skin compared with the skin before tanning and drying? 8

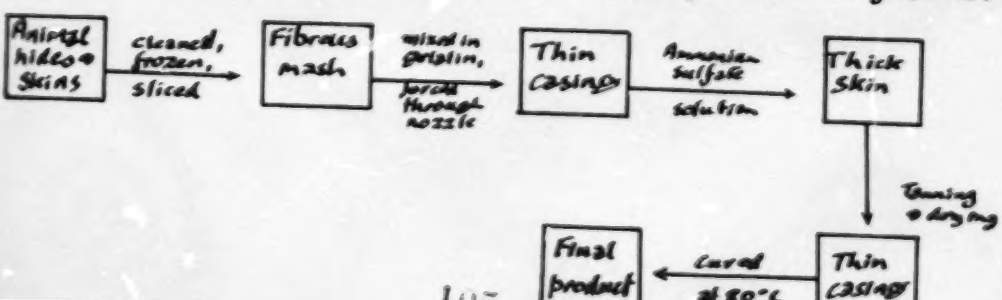
RESEARCH QUESTIONS

6. What is collagen (line 7)? Where is it found and how is it obtained?
7. What is the chemical formula for ammonium sulfate?
8. What other substances are used to make sausage skins? (Try asking your local butcher).
9. What do butchers stuff into sausage skins?
10. Sausages must be cooked thoroughly because of the risk of infection by parasites. What are these parasites called and how do they affect humans?
11. What are the advantages of using synthetic skins rather than sheep intestines?

6. Protein: found in bones, hide and tendons
7. $(NH_4)_2SO_4$
8. We don't know (sorry!)
9. Mince / meat, preservatives...
10. Tapeworms? hydatids? Flukes?

Controlled quality, less risk of parasite, regulated supply, stronger, sterile manufacture.

4.



See also exercises 29, 30, 64, 69, 148.

SOURCE: Life Science Library - Energy ★★★

ENTROPY - A HEAT DEATH. 131

When steam comes out of the spout of a kettle, its molecules are going one way - out. Within moments, however, the steam dissipates and its molecules go flying in every direction. As they spread, their heat goes to warm the cooler air. They gradually lose their useful energy - the energy which could have been used, say, to run a steam engine.

Nature has a tendency to equalise temperatures. If it were not for differences in temperature, none of our machines which convert heat to other forms of energy could operate. In the same way that water can turn a wheel only if it runs downhill, so heat can do work only when it flows from a hot place to a cold one. This principle applies not only to machines but also to nature. The constantly changing weather of our planet depends on differences in heat levels around the globe. Wind, for instance, is largely caused by hot air rising and cold air moving in to take its place.

The measure of just how evenly the heat of the universe is distributed is called entropy. This term was invented by the German physicist Clausius in 1865. Increasing entropy - the continuous dilution of heat and order has cosmic implications. For nearly a century, there has been wide-spread speculation that the whole universe might be running a self-destroying race towards maximum entropy. Eventually, according to this theory, there must come a time when the whole cosmos will level out to an absolutely uniform temperature.

When this occurs, no more work will be done. All processes will stop, and so, say some, will time.

We know that it doesn't really flow, but how about your kids?

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of the following words as used in the passage?

   molecule (line 1), dissipates (line 2), convert (line 7), principle (line 10), entropy (line 15), dilution (line 16), cosmic (line 17).

2. Where does the energy of the steam molecules go? By collision, to air molecules.

3. What is meant by nature has a tendency to equalise temperatures (line 6)? Give an example to illustrate your answer.
   Heat tends to pass from source to sink.

4. What, exactly, is the principle referred to in line 10?
   Second Law of Thermodynamics

5. The passage is headed "Entropy - A Heat Death". What do you think is meant by the phrase "A Heat Death"?
   When all things have the same temperature, heat ceases to exist.

RESEARCH QUESTIONS

6. Name a machine which man uses to convert heat into
   (a) kinetic energy — steam engine
   (b) electrical energy — thermocouple
   (c) light energy. — light bulb?

7. If the energy of molecules of heated substances goes to warm the cooler air (lines 3 and 4), and this has been occurring for many years, why isn't our atmosphere unbearably hot?
   Input from the sun, radiation to space,

Some people may be a little sensitive about the last paragraph....
See also exercise 131.

★★

IS EARTH'S OXYGEN RUNNING OUT? 132

Will man, as a result of his needless dumping of wastes and his exploitation of the Earth's resources find himself running short of oxygen and other chemicals necessary for sustaining life?

Every year we are removing more oxygen from the atmosphere by burning more fossil fuels. At the same time we are reducing the amount of oxygen going into the atmosphere by clearing a million acres of the photosynthetic plants which produce oxygen.

A decrease in the amount of oxygen in the atmosphere could also come about as a result of gradual destruction of planktonic diatoms in the oceans by toxic garbage. These planktonic diatoms produce 70% or more of the atmosphere's oxygen by photosynthesis. It is estimated that some half a million substances including materials such as pesticides, radioisotopes, and detergents are now being dumped into the oceans. The Earth's living things might not be able to adapt to many of these products. Only a few of the substances have been tested for their effects on cycles such as the oxygen cycle and the nitrogen cycle.

Man must have green plants to produce the oxygen he needs. For this reason schemes such as the UNESCO plan to develop the Amazon Basin for agriculture have been judged impracticable. Man's influence on the Earth is now so predominant that he must stop and think about the implications of his actions.

Fundamentally, the problem of exploitation of the Earth's resources comes down to the fact that the Earth is nearing its population capacity. We need co-operation between social and natural scientists to try to decide what an optimum size for the human population should be and then work out how we could achieve and maintain that number.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? exploitation (line 2), resources (line 2), planktonic diatoms (line 9), pesticides (line 12), predominant (line 20), fundamentally (line 22), population capacity (line 23).

2. What factors are contributing to the decreasing amount of oxygen in the atmosphere? Burning fossil fuels, polluting phytoplankton, deforestation.

3. What solution to the problem is proposed by the article? Last paragraph.

WHOOPS!

4. The article implies that man has been scientifically irresponsible. What form has this irresponsibility taken? Over-breeding.

RESEARCH QUESTIONS

5. Draw diagrams of the oxygen cycle and the nitrogen cycle and label them. Indicate where the cycles will be disrupted by the problems referred to in the passage. See any standard text.

6. What is meant by the term biodegradable? Make a list of substances which man uses regularly which, in your opinion, would be biodegradable.

7. What do the initials UNESCO mean? What is their origin? United Nations Educational, Scientific and Cultural Organisation

7. And what does UNESCO do?

8. What was the UNESCO plan for the Amazon Basin? Do you agree that it may had had bad effects on the future of man or was it a good idea?

8. Would crops be as effective in photosynthesising as rain-forest? Would they protect the soil?

9. What do social and natural scientists do? Who are they and what would be the role of each in solving this problem?

9. From another point of view, should we make the distinction? What sort of scientists are teachers? Most of education is clearly within the realm of social science: is the science teacher a scientist first, or a communicator about science? Can one exist without the other?

Several of M. C. Escher's lithographs, such as "Waterfall" or "Ascending and Descending" would produce interesting reactions. See your friendly art teacher or poster shop.

See also exercise 69. ★★

PERPETUAL MOTION 133

Sooner or later every child who spends time with electric motors and generators has a brilliant idea. Why not hook the shaft of the motor to the shaft of the generator so that the motor drives the generator, which generates power to drive the motor.

The young inventor does not know it, but this is simply repeating steps taken by brilliant minds over the centuries in the absorbing search for perpetual motion. It is safe to say that no machine of this sort has ever worked. Leonardo da Vinci concluded that most such schemes were bound to fail. He said "O speculators about perpetual motion, how many vain chimeras have you created in the question? Go and take you places with the seekers after gold."

The French Academy of Sciences in 1775 finally closed its doors to any more perpetual motion plans saying: "This sort of research .... has ruined more than one family, and in many cases, mechanics who might have rendered great services, have consumed their fortune, their time and their genius on it."

Neither the academy nor Leonardo knew the basic laws that deny the possibility of perpetual motion. This knowledge was to come only with a much more complete understanding of the nature of one of energy's most elusive forms, heat.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of the following words as used in the passage?
   generators (line 2), power (line 4), perpetual (line 7), chimeras (line 10).

U.S. spelling →

Classically, a chimaera is a monster with the head of a lion, body of a goat, tail of a serpent. Now "a mere wild fancy, an unfounded conception" (OED)

2. What is the design for a perpetual motion machine often thought of by students? Lines 2, 3, 4

3. What is a perpetual motion machine? What sort of fuel could be used to work one?
   An old fuel? (sorry!)

RESEARCH QUESTIONS

4. What did Leonardo mean when he said "go and take your places with the seekers after gold." (lines 10 and 11)?
   Those who sought to transmute base metals.
5. What basic laws were unknown by Leonardo and the French Academy? How are these relevant to this situation?
   friction, conservation of energy, 2nd law of thermodynamics.
6. Leonardo da Vinci, Sir William Congreve and Archimedes all designed perpetual motion machines. Find out about one of these, give a diagram of the machine saying how it was supposed to work, and why it didn't work.

Some machines exist with very clever inputs of energy from concealed air jets, or rotating magnets. These fakes can be detected with difficulty, as the "inventor" refuses access, claiming that his/her idea would be stolen.

The "drinking ostrich" relies on a concealed input of energy: the energy used in evaporating the water on the beak. (Julius Sumner Miller calls it the "drinking duck" on p. 204 of his Demonstrations in Physics, Ave Smith, 1969.)

See also exercises 77, 80, 81, 135, 137, 138, 139, 147.

SOURCE: New Horizon Library. Atoms & Energy. ★★★

RADIOACTIVE DECAY 134a

When atoms of a radioactive element produce alpha particles or beta particles, they change into different atoms.

The speed of the change varies from one radioactive element to another. It is measured by a quantity called the *half-life*. The half-life is the time it takes for half of *any* amount of an element to undergo change or radioactive decay. If the half-life of an element is one hour, for example, half of a sample of the element will change into another element in one hour. But the remaining half will not all change over the next hour. It must be considered as a separate sample, and half of it will change over the next hour that is, a quarter of the original amount, leaving a quarter. Then, over the third hour, a half of this quarter will change, leaving an eighth, and so on. As every half-life period goes by, a sample of a radioactive element decreases by a half, then a quarter, an eighth, a sixteenth, a thirty-second, a sixty-fourth, and so on.

The half-lives of some radioactive isotopes are only a fraction of a second. But others, such as uranium-238 and thorium-232 last for thousands of millions of years. By measuring the amounts of these long-lived isotopes that are left in rocks, geologists can estimate how old the rocks are and even when the Earth was formed. The half-life of uranium-238 is 4500 million years, which is about the same age as the Earth. This means that there was twice as much uranium-238 in the Earth when it was formed, and since then half of it has changed into other elements. *

A radioactive element may change into another radioactive element, which then itself changes into another, and so on. A radioactive series occurs, with a whole sequence of radioactive elements being formed, until finally one changes into an element which is not radioactive. Then the series stops. There are three natural radioactive series. They start with uranium-238, uranium-235 and thorium-232, and all end as non-radioactive isotopes of lead after many millions of years.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   radioactive (line 1), element (line 6), isotope (line 17), series (line 27).
2. What is meant by the term half-life (line 4)? What is the half-life of uranium-238?
   Lines 6-14, line 19.
3. What evidence is there that half of the earth's uranium has changed into other elements (lines 21/22)?
   Counting the isotopes of U-238 & its breakdown products
4. If bismuth-214 has a half life of 20 minutes how much bismuth-214 would remain after 1 hour if there was initially 128 grams? 16 grams.
5. How long would it take bismuth-210 to decay to a sixty-fourth of its original mass? Bismuth-210 has a half life of 5 days.
   30 days.

* Methods such as this won't work in the future, so we are using U-238 in a much faster way. See also the note on #81.

RESEARCH QUESTIONS

134b

6. Explain how the half-life concept is used to determine the age of rock and fossils. What assumptions does this method make? That the rate of decay is constant.

7. In the terms uranium-238 (line 16) and thorium-232 (line 16), what do the numbers stand for? Atomic mass

See #116, Q. 8 note.

8. What changes occur in the nucleus of an atom when it undergoes

   (a) alpha decay?
   (b) beta decay?
   (c) Explain the structure of each particle.

See any standard text.

Q. 7 - Say how much detail you want.

See also exercises 69, 137, 138, 139.

SOURCE: New Horizon Library "Atoms and Energy" ★★★

135a

NUCLEAR ENERGY : BOON OR THREAT?

Supplies of coal and oil are limited and our demand for energy is always increasing. Many nations have to import large amounts of fuel such as oil to keep up industrial production and living standards. Faced with diminishing reserves and uncertainties about the fuel supply from abroad, these countries have looked for other ways of obtaining enough energy. Producing electricity by nuclear fission is the most widely used at the moment. Without power generated by fission, the lives of many people would become less comfortable. An extra benefit is that nuclear power stations do not pollute the air as coal-fired and oil-fired stations do.

Nuclear power helps us in other ways. The production of radioisotopes has advanced industry and medicine, and new uses are being found for them all the time. And there are possibilities that nuclear explosions could have important peaceful uses. Underground explosions could help break up mineral deposits and make them easier to obtain. Canals could be dug and harbours blasted in solid rock more easily with nuclear explosives than with ordinary explosives. The explosions can be made to produce little radioactivity, but more research is needed before they can be used safely.

Safety is the most important question that is raised about nuclear energy. The production and use of nuclear energy always releases radiation, and radiation is very harmful to life. Unless nuclear energy is strictly controlled, it presents a grave threat to us all. One problem is that it is difficult to find out whether there is a safe level of radiation that people can absorb without harm. The longer we live with nuclear energy, the more we find out about the effects of radiation. And it is possible that low levels of radiation may have long-term harmful effects. Some people believe that the tiny increases in radiation that have occurred since man began to use nuclear energy have caused an increase in birth defects. Although safe limits are published for radioactivity, it is possible that no amount of radiation however small, is harmless.

Radiation may enter our bodies from many causes. A little inevitably leaks from nuclear power stations, however strong their safety measures. There have been small accidents at power stations that resulted in some radioactivity being released.

The waste that nuclear stations produce is highly radioactive. The volume of waste is not large but the radioactivity is intense and extremely dangerous. Nuclear waste is usually stored in tanks with thick walls that absorb the radioactivity. But tanks corrode and may eventually split open, and radioactivity can last for thousands of years. Nuclear authorities are investigating dumping as a way of disposing of nuclear waste. It might be buried in the ground or dumped into the sea. But the movements of ground and seas are too uncertain to make this method of waste disposal completely safe. As nuclear power increases, waste disposal problems will increase.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words and terms mean as they are used in the passage?

   industrial production (line 3), diminishing (line 4), nuclear fission (line 6), radioisotopes (line 10), corrode (line 37), disposing (line 39).

2. Name four advantages of nuclear energy mentioned in the passage.

3. Why is the disposal of nuclear waste material a problem?

4. Why are supplies of coal and oil limited (line 1)?

2. Power, isotopes for industry and medicine, use in construction.
3. Because of long-term dangers.
4. When we've used what is there, that's it folks!

A question of risk: how many deaths are we willing to accept? This year, more than 3000 people will die on the roads. Another 3000 from lung cancer, 600 of cirrhosis of the liver. But we still accept cars, tobacco and alcohol. Why? Because this appears to be an acceptable level of risk?

RESEARCH QUESTIONS 135b

5. Briefly describe the various types of radioactivity and their effects on living cells.

6. (a) Explain in more detail what nuclear fission is. Give an example to illustrate your answer.
   (b) What is the difference between nuclear fission and nuclear fusion?
   (c) Which would be a better source of nuclear power? Why?
   (d) Why don't we use nuclear fusion as a source of power at present?

7. How safe are the world's nuclear reactors? Make a list of nuclear "accidents" which have occurred in the last 10 years. Have any lives been lost? What damage was done?

8. What do nuclear authorities mean by dumping (line 39)? What precautions are taken in dumping nuclear wastes?

Any balanced study of the pros & cons of nuclear energy should look at

* carcinogens in coal and oil fumes and ash;
* other irritants - " - " - " - " ;
* deaths in coal mining;
* deaths in coal and oil power generation;
* loss of material during nuclear power generation;
* deaths in uranium mining;
* deaths in nuclear power generation;
* persistence of dangerous by-products;
* effects which take time to appear - silicosis (coal-miners), cancer (uranium workers);
* difficulties in detecting low-level effects and assigning them to a particular cause.

A letter to any of the uranium mining companies will produce a handy set of pro-nuclear details, or you can write to the Uranium Producers' Forum, 390 Lonsdale St., Melbourne. The other side is well-covered in Movement Against Uranium Mining's leaflets - "Ordinary Person's Guide to Uranium Mining" and "Understanding Uranium", 60 cents each. They are in the Trades Hall, Goulburn St., Sydney (Box K133, Haymarket) and on the phone at 267-2459.

A controversial person is Ernest Sternglass: see *New Scientist* 24 April 1980, p. 180 and 197-199.

However you approach this topic, you are likely to be assailed by parents - if both sides attack you, you will know that your coverage is balanced. Good luck!

See also exercises 54, 55, 140.

SOURCE: "Sun-Herald" August 27th 1978. ★★

136

NEW BID TO STEM NUCLEAR LEAK

ROCK, KANSAS, Saturday (AAP). - Airforce workers dumped thousands of litres of ammonium hydroxide into an underground Titan II missile silo today, hoping to neutralise leaked rocket fuel that killed one serviceman and seriously injured two others.

Clouds of billowing smoke and steam rose above the underground missile site near Wichita, a result of the heat created by the chemical reaction of the ammonium hydroxide being poured through the open silo doors with the poisonous propellant dinitrogen tetroxide.

Air Force officials said steam clouds created by the neutralisation were harmless and the substance formed by the reaction was ammonium nitrate, a basic fertiliser.

"There's no danger at all to this neutralisation we're doing. It's perfectly safe," said a Strategic Air Command spokesman.

On Thursday, a caustic corrosive orange cloud of dinitrogen tetroxide forced hundreds of nearby residents to flee for their lives.

Those evacuated were kept from returning today as the dumping began and no air force officials were willing to predict when they could come back.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words mean as used in the article?
   silo (line 2), neutralise (line 3), billowing (line 5), propellant (line 8), basic (line 11), caustic (line 14) corrosive (line 14), evacuated (line 16).

2. Name a product of the neutralisation reaction.
   Line 10

3. Was heat absorbed or liberated during this reaction? Give a piece of evidence to support your answer.
   Line 5

4. A textbook gives the following changes to dinitrogen tetroxide with increasing temperature:

-10°C	colourless or very pale yellow solid.
10°C	yellow liquid.
22°C	boils with an orange colour.
30°C	a reddish brown gas.
40°C	nearly black gas.

   Somewhere here

   From this information, at what temperature was the dinitrogen tetroxide which forced hundreds of residents to flee?

5. The heading of the article states that there was "a nuclear leak" at the missile silo. Comment on the accuracy of this heading. Where else does "nuclear" appear?

RESEARCH QUESTIONS

6. What are the chemical formulae for the substances mentioned in this reaction: Ammonium hydroxide, dinitrogen tetroxide, ammonium nitrate? NH_4OH, N_2O_4, NH_4NO_3

This may be a little heavy for some students.

7. Dinitrogen tetroxide was used as an oxidiser in the propulsion system of the first lunar landing craft.
   (i) What is an oxidiser?
   (ii) Find out more about dinitrogen tetroxide.

See also exercises 135, 139

See q. 2.

SOURCE: "The Sun" Friday May 4th, 1979 p. 13 ★★

MYSTERY 'LEAKS' IN 15 PLANTS 137

Scientists are baffled by a corosion problem, causing pipes to crack and leak small amounts of radioactive water, in at least 15 nuclear power plants in the United States.

Meanwhile, in Britain, Dungeness Nuclear Power Station, has been shut down because of faults in the cooling system caused by cracks in one of the reactors.

The problem in the United States has caused extensive pipe damage in the steam generators of five nuclear power plants and "minor" damage at 20 other plants.

Darrell Eisenhut, Deputy Director of the Nuclear Regulatory Commission said a chemical reaction involving acids- chlorine and salt causes a corrisive build-up between the pipes and their metal fittings, creating pressure.

WHOOPS to be corrected

He said the only solution now appears to be replacing the pipes.

Scientists have been unable to develop a chemical to dissolve the corrosion build-up, to be added.

At Dungeness, minute cracks in one of the "A" reactors has led to an 8-month shutdown, costing $555,000 a week.

The plant produces Britain's cheapest electricity.

A spokesman said of the cracks: "You might almost call them scratches".

He stressed there was "absolutely no question of a safety or radiation hazard at all."

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words mean as used in the article? baffled (line 1), radioactive (line 2), reactors (line 6) extensive (line 7), Generators (line 8), hazard (line 21)

2. There is a spelling mistake in the first paragraph. When you have found it write the word correctly. What does it mean? corrosion

3. What is causing the pipes to crack and leak? "corrosion"

4. Why should scientists be worried about this leak? 4. Danger if any escapes, both to health and to P.R.!

5. What have scientists tried to do to overcome this problem? Identify the cause, seek a chemical cure.

6. Calculate the approximate cost of the eight-month shutdown of the Dungeness "A" reactor. $19240 000 - say 20 million?

7. Who stressed to the reporters that there was "absolutely no question of a safety or radiation hazard at all"? Why do you think he stressed this point to them? After the story opposite, can you blame him?

RESEARCH QUESTIONS

8. Draw a diagram of a nuclear reactor. Label your diagram and explain how the reactor works.

On January 13, 1980, Dungeness was closed due to cracks in the cooling system. According to ABC News, the cost was "$160 000 a day"....

See also exercises 60, 135, 139

SOURCE: "Sydney Morning Herald" 18th June, 1974 p.10. ★★★

138a

PLAUSIBLE THEORY ON LUNG CANCER

A recent article in the scientific journal "Nature" written by Dr. Edward Martell, of the US National Centre for Atmospheric Research in Boulder, Colorado, offers a plausible theory to explain how smoking may actually cause lung cancer.

There is no doubt whatsoever that smokers have a greatly increased chance of contracting lung cancer than non-smokers. Yet such a correlation does not necessarily mean that smoking is the direct cause of lung cancer; it could be that some other factor promotes both the inclination to smoke and an increased probability of contracting the disease.

It is because of such arguments that medical research has been directed towards establishing whether smoking is a direct cause of lung cancer.

One theory is that the tars carried in tobacco smoke, some of which are deposited on the walls of the lungs, are a prime cause of cancer. It has been established, for example by experiments on mice, that such tars have carcinogenic effects.

In his article in "Nature", Dr. Martell refers to scientific evidence that tobacco, cigarette smoke and smokers' lungs contain a radioactive isotope of lead-210. This isotope decays radioactively to polonium-210, which is an emitter of extremely strong radiation in the form of so-called alpha particles - which are in fact the nuclei of helium. It is well known that radioactive substances which emit alpha particles are very prone to produce cancerous conditions.

Of all the theories which attempt to connect smoking as a direct cause of lung cancer none has as yet explained the long delay between smoking and onset of cancer. Martell's theory does this.

The lead-210 converts very slowly to polonium-210 and has what is known as a half-life of 21 years. This means that of a given amount of lead-210, one half will have converted in 21 years.

Once the polonium-210 is formed, however, it emits its alpha particles relatively rapidly with a half-life of only 138 days, ending up in the form of stable lead-206. This alpha particle radiation, which may induce the cancer, can occur long after the radioactive particle was deposited.

As early as 1965 the well-known New Zealand scientist Sir Ernest Marsden, writing in the "New Zealand Medical Journal" put forward a theory somewhat similar to Dr. Martell's.

Marsden's article was entitled, "Some aspects of the relationship of radioactivity to lung cancer" and suggested that polonium-210 was "present in many tobaccos in quantities sufficient to suggest that these may well be responsible for most of the carcinogenic effects observed".

The Marsden article received a considerable amount of publicity, but eventually his theory was discounted on several grounds - one being the relatively short half-life of polonium-210. This would mean that, even if the substance were at one stage present in tobacco plants it would have decayed before the cigarette was smoked.

The new theory, however, completely overcomes this difficulty by attributing the effect to the long-lived lead-210, of which polonium-210 is an eventual by-product. Moreover, lead is well known to accumulate in the body and a smoker could have a significant accumulation in his lungs.

Precisely how the lead-210 finds its way into or attaches itself onto the tobacco leaves, and thus into the smoker's lungs is a subject yet to be studied.

The open line indicate that the passage continues on the next page....

138b

At the same time, Martell's paper highlights an additional possible danger of ordinary lead pollution which exists for many reasons, of which one of the major ones results from lead additives in petrol.

55

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
plausible (line 3), correlation (line 6), carcinogenic (line 16), isotope (line 20), helium (line 21)

2. Sir Ernest Marsden proposed in 1965 that the radioactive Polonium-210 produced from lead in tobacco causes lung cancer. Why was his theory discounted? Lines 41-44

3. What alternative theory to Marsden's is proposed in the article? Lead 210 as a source of Po-210
Why is it a more acceptable theory? Lines 46-49

4. What other important source of lead-apart from tobacco smoke - is mentioned in the article? Petrol additives

RESEARCH QUESTIONS

5. The article points out that smoking is known to be correlated with lung cancer, but it isn't known whether smoking causes lung cancer. Give another example of this. see below.

6. "... radioactive substances which emit alpha particles are very prone to produce cancerous conditions". (lines 21/2/3). Find out how they do this. Presumably by attacking the DNA in some way - this is what chemical carcinogens do.

7. Write nuclear equations for the radioactive decay of:

(i) Lead-210 to Polonium-210
(ii) Polonium-210 to Lead-206.

6. Most statistical text-books have examples, but we like:

* stork nests in & around Stockholm and number of babies born (rural areas have more storks AND more births) ($r > .80$)
* number of fire engines at a fire and damage caused ($r = .90$)
* number of iron ingots shipped from Pennsylvania to California 1900-1970 and the number of registered prostitutes in Buenos Aires for the same period
* number of radio listeners licences in the UK, and the number of admissions to mental institutions 1930-1950

7. $Pb^{210}_{82} \xrightarrow{\beta} Bi^{210}_{83} \xrightarrow{\beta} Po^{210}_{84} \xrightarrow{\alpha} Pb^{206}_{82}$

★★★

SOURCE: Adopted from New Horizon Library. Atoms & Energy.

RADIATION AND ITS DANGERS

139a

When alpha particles strike atoms, they change the nuclei of the atoms turning them into atoms of other elements. If beta particles (electrons) strike atoms, they will give the atoms an electric charge. Alpha particles also charge atoms, because they are electrically charged themselves.

If alpha and beta rays strike the human body, the particles in them change the atoms there. This can be very dangerous, because our bodies are made up of many chemical compounds working together in a delicate balance. If the compounds in our bodies suddenly start changing, illness, perhaps even death, may result.

Rays and particles like these are often called *radiation*. There is a third kind of radiation produced when nuclei change - gamma rays. (Gamma is the third letter of the Greek alphabet and written γ.) Gamma rays are not streams of tiny particles like alpha and beta rays. They are a form of very strong X-rays and, like X-rays, gamma rays can easily penetrate matter.

Alpha particles are not a great hazard to life. They are not very penetrating and are in fact stopped by the outer layer of the skin. Beta rays are more penetrating and can get inside the skin. But gamma rays are so penetrating that they can pass right through the body, just as X-rays can. They cause harm to the atoms in the body. X-rays also cause harm, and this is why you should avoid having too may X-ray examinations.

Protection from Radiation

Nuclear physicists and people who work at nuclear power stations all face danger from radiation. The materials they use are often radioactive and produce radiation. In fact, we all receive a small amount of radiation every day. This radiation comes from the natural radioactivity of some minerals in the ground, and also from cosmic rays and other rays striking the Earth from outer space. But this natural radiation, which is known as background radiation, is very slight, and is harmless.

Man-made radioactivity is far stronger than natural radioactivity. People who have to handle radioactive materials do so with special tools and shield themselves behind thick screens that absorb the radiation. Workers who have to go into radioactive areas wear special plastic suits with their own air supply. The suits are washed down to remove radioactive particles before they are taken off.

All the people in nuclear power stations and nuclear laboratories have instruments to detect radiation. They each wear a film badge - a small piece of film inside a plastic holder. The film is developed at regular intervals and replaced with a new piece. If the wearer of the badge has received any radiation, the film appears black when developed. Other instruments that immediately detect radiation include the Geiger counter. This is an electronic instrument and shows how strong the radiation is. Among its uses, the Geiger counter is employed in prospecting for radioactive minerals such as uranium.

The designers of nuclear buildings try to make sure that no radioactive dust or other dangerous materials can leak into the air. Radioactive places, and containers of radioactive materials, are all marked with the international radioactivity symbol to warn people to take care.

This is incorrect. If you are not setting question 6, this should be mentioned.

DO NOT WRITE ANY ANSERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? penetrate (line 16), atoms (line 21), radioactive (line 25), minerals (line 28), cosmic (line 28).
2. Draw up a table which shows: Two types of radioactivity. Nature of the radioactivity, Penetrating power, Protections against.
3. Why is radioactivity dangerous to life? What sort of things can occur to a body exposed to lots of radiation? Lines 6-10
4. What is background radiation (line 30)? Lines 27-30
5. How are people who work in nuclear establishments protected from radioactivity? Lines 31-36

We should all get more exercises like this! →

Here are all three for question 2:

Type of radioactivity	Nature of radioactivity	Penetrating power	Protection against
Alpha	helium nuclei (not given)	can't pass skin	—
Beta	electrons	can pass skin	plastic suits
Gamma	"very strong" X-rays	can pass through body	thick screens and shields

RESEARCH QUESTIONS

139b

6. The article states that background radiation is ... harmless (line 30).
Is this so? Explain your answer.

7. Radiation can be used to man's advantage. List two situations where man does use radioactivity, but give only one medical use.

8. What does the international radioactivity symbol look like?
Why is it used?
Where is it used?

5. Special tools, special protection, film badges, G-M counters, film badges, own air supply, wash down, etc..

6. Doesn't cause assignable illness or death. BUT there is a base level for leukaemia and other such illnesses. Any increase in radiation raises this base level. This can be shown, for example, with mutation rates, although a paper by Russell Proc. Amer. Phil. Soc., 107 : 11-17, 1963, appears to contradict this. (Royal Society of NSW Library holds this journal.)
In the end, is it logical to assume that the background level (which varies anyway) is just at the threshold? See the note on #135 about risk.

7. Source of heat and power, testing gas flow in pipelines (as a tracer), also artesian flow (in Darling Downs), testing welds in steel pipe, chemical analyses of biochemical pathways.

8. To warn people of danger.
It should appear on doors, walls and elsewhere as necessary of buildings, on boxes and containers, and transport vehicles if necessary, when (and only when) radioactive materials are present. It should not be used on notices proclaiming nuclear-free zones unless crossed by a bold slash. Remember the boy who called "Wolf".

See also 54, 55, 136, note to q. 8, 84.

SOURCE: Sun-Herald September 10th, 1978. ★★

SCARE ON DEADLY PELLETS 140

PERTH - Cyanide pellets, giving off a highly toxic and flammable gas, created a major emergency yesterday when they were scattered beside the Great Eastern Highway.

The emergency occurred at Wooroloo, 56 km from Perth.

Twelve big drums of sodium cyanide burst when they fell from a truck about 3a.m.

The gas, given off when the chemical is wet by rain, is the same used in gas chambers for executions.

Firemen covered the pellets with protective sheets to shelter them from rain.

They were dressed in special protective clothing in case the gas blew up.

The highway was blocked off for more than seven hours.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words mean as used in the article? pellets (line 1), toxic (line 1), flammable (line 1), protective (line 9).

Line 7

2. Does sodium cyanide react with water? How do you know?

To keep off the rain

3. Why did the firemen cover the pellets with protective sheets?

Dark + wet

4. What *two* conditions at the time of the accident would make it difficult for the firemen to clean up the chemical?

5. i. What type of article is this? Persuasive? Informative? Critical? Derogatory?
   ii. Is this article objective or subjective? (we think so!)

RESEARCH QUESTIONS

Prussic acid (HCN) - see exercise 84, note to q. 8

6. Find out the name of the gas used in gas chambers.

7. Write a balanced equation for the reaction between the sodium cyanide and the rain (water).

$NaCN(aq.) + H_2O(l) \rightarrow HCN(g) + NaOH(aq.)$

See also exercises 142, 143

★★★

BIOLOGICAL CONTROL 141

The most spectacular example of biological control was achieved in California. In the 1880s, the citrus groves in California became infested with fluted scale. The infestation was so heavy that the survival of the industry was threatened.

It was noticed that the scale insect was also present in Australia. Here, however, it did not affect the citrus trees. It was thought that perhaps the fluted scale had been introduced into California without its natural enemies. It was also thought that if these natural enemies could be brought in, a balance might be restored.

An entomologist was sent to Australia from California. He soon discovered the parasitic fly *Cryptochaetum*. This insect specialised in laying its eggs in scale insects. He also noticed the small ladybird beetle *Rodolia cardinalis*. This preys exclusively on the larvae and adults of the scale insects.

A few of each were sent to California and released on an infested tree enclosed in a tent. Within two weeks it was free of scale insects. The beetles were then released in a small orchard where the results were the same. They spread and were carried from one grove to the next. Within a year it was clear that the citrus industry had been saved. The fluted scale had virtually disappeared.

The same triumph has been repeated all over the world wherever the scale insect was imported without its natural enemies.

There are two very good films (with the same title, we think) available from Burwood: "The Biological Control of Insects". How about a tie-in.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words or phrases mean as they are used in the passage?

   citrus (line 2), infestation (line 3), natural enemies (line 8), parasitic (line 11), exclusively (line 13).

2. This article gives us a good example of a practical application of the scientific method. Use the information in the passage to identify these aspects of the scientific method:

   (i) an initial observation 2, 3-5, 6
   (ii) a problem identified 3, 4
   (iii) research into the problem 10-14
   (iv) formation of hypotheses 6-9
   (v) controlled experiment 15, 16
   (vi) experimental results 16
   (vii) further experimentation 17
   (viii) experimental results 18, 19, 20 (?)
   (ix) conclusion. 21/22, maybe 20 (?)

RESEARCH QUESTIONS

3. What are the characteristics of a biological control?

Preys exclusively (or almost so) on pest.

4. Are there any dangers to avoid when using a biological control?

5. ~~Find out about when instances~~ What are some examples of biological control are which have been used in Australia.

WHOOPS AND OUCH! Prickly pear → Cactoblastis, Cane toad → cane beetle (a flop!), Dung beetles, Sirex → Pinus radiata. Several attempts to control Lantana (local birds loved the new foods!)

6. Are all the agents of biological control parasites? Is this an essential characteristic of biological control? Explain.

6. No: the dung beetle is a competitor. Others may be predators, but parasitism is better: more obligatory: usually they are host-specific. The cane toad wasn't, and now Queensland is knee-deep in cane toads.

See also exercises 141, 143.

SOURCE: "Sun-Herald, Nov. 12, 1978.

★★

142a

VEGEMITE IN WAR ON GARDEN PESTS

Vegemite - that great staple of the Australian diet - might soon become the new wonder weapon of farmers and home gardeners in their battle against crop-devouring pests.

It seems the savoury spread we lavish on toast and sandwiches is equally as tasty to some tiny insect predators.

Melbourne zoologist, Dr. Tim New, says diluted with water and sprayed on fields of crops, Vegemite attracts green lacewings - helpful little insects scientifically known as Neuroptera.

In the adult stage they thrive on solutions of yeast hydrolysates - and that includes Vegemite.

But their hungry young have an insatiable appetite for garden pests such as aphids, caterpillars, and other scale and soft-bodied insects.

"The idea is to encourage these natural predators into a crop so they are ready and waiting when the pests arrive", said Dr. New, a senior lecturer in zoology at La Trobe University.

"Most pest infestations occur at predictable times of the year and its only when they reach plague proportions that the natural predators appear.

"By this time, the pests have already done the damage.

"If we supply the predators with a nourishing food source, such as Vegemite, early in the season, they will stay and breed and be on hand to deal with any pest infestation."

Dr. New says using hydrolysed yeast sprays would help lower the levels of environmental pollution caused by the present reliance of broad-spectrum chemical herbicides and pesticides.

Although the Vegemite idea seems a little far-fetched, Dr. New says the method has been tried and proven in the United States.

However, the Americans use a different commercial product similar in its constitution to Vegemite.

Dr. New said it was becoming increasingly urgent for gardeners to realise that using chemical sprays was like deploying land mines against stray cats.

"The chemicals not only kill pests but also the natural predators," he said.

"They can be harmful to bees and will probably take years off your own life.

"So little research has been done on the long term effects of these chemicals and there's a strong possibility that some of them may cause genetic defects."

He believes that within a few years most insect pests will become immune to chemical sprays and that science will have to find other viable alternatives.

The third paragraph could have been better put! A nice extra question - rewrite and/or repunctuate to clarify.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

Is there a linguisto-geographical boundary* between those who say "Marmite" and those who say "Vegemite". (In France, Languedoc was so-called because they didn't say "oui".) Or is it socio-economic? A political marker like pronouncing "pseudo" "swahdo"? Who will get the first Ph.D (Paper-hanger's Delight) for solving this problem?

* Do you eat Poloni or Devon? Wash in a tub or a trough in the laundry or wash-house? Wear costies, bathers or swimmers?

142b

1. What do the following words mean as they are used in the passage?

   staple (line 1), devouring (line 3), lavish (line 4), predators (line 5), insatiable (line 11), infestations (line 16), constitution (line 28), deploying (line 30), viable (line 39).

2. List the advantages of spraying a garden with diluted Vegemite instead of insecticide. Low pollution, predators build up in advance.

3. What does the term broad-spectrum (line 23) mean? Aimed at a wide range

4. Which of the following food chains can be constructed from the information in the article?

   A. Vegemite → aphids → green lacewings.
   B. Vegemite → green lacewings → aphids.
   C. Crops → aphids → scale insects.
   D. Crops → caterpillars → green lacewings.

5. Find the *analogy* used in this article. Is this analogy effective? Explain. Lines 29 & 30 Non-selective destruction. See also exercises 90 & 124.

6. In the article, Dr. New lists five disadvantages of the use of chemical insecticides. What are they?
Broad spectrum, polluting, kill predators, kill bees, may harm us, cause genetic defects (?), insects can become immune.

RESEARCH QUESTIONS

7. (i) What are yeast hydrolysates (line 9)?
   (ii) Name two other foods which contain yeast hydrolysates. Marmite, Promite
   (iii) Can these foods be used instead of Vegemite on the garden? Presumably - what a lovely experiment to try!

8. Draw a diagram of the green lacewing. See Imms Outlines of Entomology p. 158

9. Why do you think the insect is called the lacewing? Looks like an antimacassar!

10. What are some of the characteristics of the adult green lacewing? See Insects of Australia (CSIRO/MUP) - look under Chrysophidae

11. The larval stage of the lacewing has an interesting food collecting and eating behaviour. What is it? See below

12. In the last paragraph, Dr. New stated that alternatives to chemicals will need to be found. What are some of the non-chemical ways scientists are using to control insect pests at present? See ex. 114

8. Chapter 29 of Insects of Australia p. 474 for adults, pp. 486, 489 and 491 for larvae. One family (Myrmeleontidae) are the ant-lions. The N. Hemisphere equivalent is a Dipteran: lovely case of convergent evolution.

*9 Please, teach, what's an antimacassar? A lace mat placed on settees, lounges, chairs to ward off hair oil originating in Macassar. Now gone, like net covers edged with glass beads on the milk and sugar....

11. Some species of Chrysophinae cover themselves with detritus, mostly sucked out bodies of prey. Pupal coccoon similarly covered.

See also exercises 141, 142.

★★★

STERILE MALE TECHNIQUE WORKS WITH RATS 143a

The war on rats gains a new weapon with a chemical which with one dose leaves male rats permanently sterile. Except for this key point, treated rats are as healthy, energetic, and as aggressive as before and maintain their previous position in the rat population.

It has been recognised for some time that sterile males retained in a population are probably more effective in controlling its number than if the same number of fertile males were removed. Sterile animals continue to compete for territory, food, social order and most importantly, for sexual partners. In the case of rats the number of litters is reduced because female rats after mating with sterile males develop a false pregnancy which prevents further mating with other males. This type of population control has been effectively carried out with various fly species over local areas by releasing multitudes of artificially bred, but sterilised, insects.

The chemical developed against the rat is a member of the chlorohydrin family and has been investigated by the Upjohn Corporation of Kalamazoo. The drug (3-chloro- 1, 2- propanediol) causes lesions in the male rat's reproductive tract which results in permanent blockage preventing sperm release. Although the testing of the chemical is still proceeding it has been proved to be relatively non-toxic to wildlife, domestic animals and man.

Being effective after just one dose is perhaps the greatest asset of this chemical. Present effective rat poisons are of the cumulative type - they require repeated ingestions. The anti-coagulants warfarin and fumarin are examples, and often rats become bait-shy before enough is consumed to cause death.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of these words as they are used in the passage?

   sterile (line 2), territory (line 8), litters (line 9), multitudes (line 13), lesions (line 16), cumulative (line 21), ingestions (line 22).

2. Explain what is meany by the following terms:

   false pregnancy (line 10), reproductive tract (lines 16/17)
   bait-shy (line 23)

2. See opposite

3. The word *family* (line 15) is used in this article with a chemical meaning. Explain what is meany by a 'family' of chemical substances.

3. Group of chemicals with similar properties (and often similar preparation).

4. What is meant by the term *anti-coagulant* (line 22)?
   How do anti-coagulants work?

   Prevent blood clotting *

5. What advantage has the new chemical over previous chemicals used to control rat populations?

   One dose is enough

6. Why is the fact that the chemical is effective after one dose such an asset?

   Bait shyness

7. Why is it important that treated rats remain healthy, energetic, and as aggressive as before (line 3)?

So that the rat "society" is maintained.

Heparin is often used in humans to prevent thrombosis, and warfarin is used sometimes (we gather). These are anti-coagulants, and the rat-poison gives a much larger dose per kg of body weight, so that the rat haemorrhages, gets thirsty, goes out for a drink and expires. You have not "smelt a rat" until one has died inside your cavity wall.

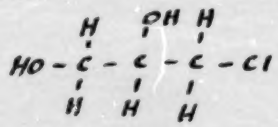
143b

RESEARCH QUESTIONS

8. This method of controlling pests is often called *biological control*. Why do you think this name is used?
see ex. 141

9. Describe one example of biological control of insect pests, explaining how it works and why it is used.
see ex 141 & ex 142.

10. For Chemistry Students. Draw the structural formula of the drug 3- chloro - 1, 2- propanediol (line 16) mentioned in this article.



2. False pregnancy is well-described in Who's Afraid of Virginia Woolf? The female shows all the signs of pregnancy except foetal implantation and development.

Reproductive Fract - in the male (the context here) it is probably sufficient to say the "Tube" from Testis to penis.

Bait-shy - once baited, twice shy. Rats explore new food, and often merely become sick due to the small dose ingested. After that, they avoid the food.

See also exercise 113, and exercise 36 for details of this excellent series.

SOURCE: The Australian Museum Leaflet No. 18, February 1968. ★★

144a

THE FLUTEMOUTH

THE flute-like snout with a small mouth at the end of its tube, the long cylindrical body and the weak fins are characteristic of the Flutemouth. It is unique among fishes because at the fork of the tail a long ray extends like a filament.

The Flutemouth is not uncommon along our rocky coastlines. It is sometimes cast ashore after heavy weather. Occasionally it takes a hook with a fish bait. It was called "The Tobacco Pipe Fish" by the men of the First Fleet, and was figured as such in John White's *Journal of a Voyage to New South Wales*, published in 1790. The Flutemouth grows to about 1.8 metres in length, 3.5 kilograms in weight, and may be brown or pink in colour. It has the ability to change its tones to harmonize with its surroundings. It is found around the northern coasts of Australia, and at Lord Howe Island, and elsewhere in the tropics, ranging from shallow water down to about 90 metres. At these depths it is preyed upon by Saw-sharks and large fishes. The Flutemouth eats small fishes and other marine animals, and is itself good eating. It is distantly related to the Sea-horses and Pipefishes.

There are two Australian species, the common brown *Fistularia immaculata* Cuvier, 1816, usually found on New South Wales beaches in winter, and the rare Red Flutemouth, *F. villosa* Klunzinger, 1871, more of a tropical species, with rougher skin.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

2. One picture is worth a thousand words.

1. What is the meaning of the following words, as used in the article?
   snout (line 1), characteristic (line 2), filament (line 4), harmonise (line 12), preyed (line 15).
2. Why is this fish called a Flutemouth?
3. What makes the Flutemouth one of a kind among fishes?
4. What does the author mean by the words distantly related (line 18)?
   Line 4
5. What do you think F. stands for in *F. villosa* (line 21)?

Fistularia

A more recent edition of this leaflet, June 1973, has just reached us. Fistularia immaculata is there called Fistularia petimba Lacepede, 1803. Now let's see, how do those nomenclature rules go again ....?

144b

6. The Flutemouth shown in the diagram was caught off Botany Bay, New South Wales. Which of the two species mentioned in the article is it more likely to be? *E. immaculata*

7. (a) What is the length of the Flutemouth in the diagram? GPW's scale mark is one inch (2·5cm)

   (b) Is it a fully grown specimen? Explain. Specimen is ~60 cm long

8. Estimate the approximate mass of the Flutemouth in the diagram. ~½ kg

---

RESEARCH QUESTIONS

9. Explain what is meant by the term: *Fistularia immaculata* Cuvier 1816 (lines 19 and 20). *

10. There is an inaccuracy in line 11. What is it?
"kilograms in weight"

11. The following is a diagram of the snout of a specimen of *Fistularia villosa* drawn to the same scale as the previous diagram.

Described in the leaflet as "slightly larger"

Give an estimate for the length of this specimen. So 75 cm?

"GPW" who drew the pictures here was Gilbert Percy Whitley (1903-75). See Proceedings of the Linnean Society of NSW, 101, 256-260, for details of his life and work.

* The International Rules of Botanical Nomenclature are fairly available: See C. H. M. Lawrence Taxonomy of Vascular Plants** p. 200. In general, Zoology rules are similar (but much harder to find!). As this goes to press, we're still checking.....

** Macmillan, 1960

See also exercise 146.

SOURCE: How and Why Wonder Book of Light and Colour.

★

145

SHADOWS

Look at someone walking down a road in the sunlight and you will see a shadow. Now suppose you watched two people carrying a 2 metre pane of glass between them. You would see the shadow of each person 2 metres apart but there would be no shadow of the pane of glass.

Shadows are easily explained if we consider that light travels in a straight line. We also know that light passes through some objects and not through others.

When light strikes an object and passes through it unchanged, we say that the object is transparent. Most glass is transparent, and it is for this reason that you would not see the shadow of the pane which the people were carrying. Another transparent material is air. Another is clear water.

On the other hand some materials do not let light pass through them at all. They stop light just as you would catch a ball that was being thrown to someone standing behind you. Such materials are called opaque. Our bodies, like steel, wood, rocks, concrete and cardboard, are opaque, and therefore do not permit light to pass through them. An opaque object casts a shadow.

3.

Transparent: Glass, water, air

Opaque: bodies, steel, wood, rocks, concrete, cardboard

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? pane (line 2), transparent (line 9), materials (line 14), opaque (line 14), permit (line 16), casts (line 16)

2. Two properties of light cause shadows. What are they?

3. The article mentions several transparent objects or materials and several opaque materials. Make a table with two columns headed "Transparent Materials" and "Opaque Materials". In the table list the materials mentioned in the passage in the correct column and add more until you have 10 of each.

4. Why do you cast a shadow, when a pane of glass does not?

4. Because we are opaque. Why are we opaque? Because we couldn't see if our eyes were transparent!

RESEARCH QUESTIONS

5. (a) Give 5 different uses for transparent materials.
(b) Give 5 situations where the use of transparent materials would not be satisfactory.

5(a) windows, covers on things to be seen, lamp covers, spectacles, light bulbs

6. What is a *translucent* material?
Give an example of such a material.
Why are bathroom windows generally made from translucent glass?

5(b) clothes, camera cases, darkroom walls, cinema ceilings, bedroom curtains, cinema screens, politicians....

6. One which transmits light while scrambling it.
Example: milk.
Because sheets of milky ice melt in the frame? Because people don't like being seen while they shave? (They could always grow a beard!)

See also exercises 45, 46, 145.

SOURCE: Light and Colour, F. Healey, Hart Davies 1962. ★

REFLECTION 146

When you comb your hair in front of a mirror you can see yourself because the mirror throws back the light. This is called *reflection*. We say the mirror reflects light. If you stand to the side of a mirror and look into it you can't see yourself. What you do see is anything on the other side of the mirror reflected in it.

This is rather like kicking a ball against a wall. If you kick the ball straight at the wall it will come back to you, but if you kick it sideways it will hit the wall then bounce away from you. Light behaves just like a ball.

Almost everything reflects light. If the things around us did not reflect light we could not see them. Without reflection the world would always be dark. When you look at a house or flowers or trees in a garden, or a plane in the sky, you can see these things because they reflect the sunlight. Some things reflect little light, some reflect a lot. A mirror reflects nearly all the light.

Dust in the air reflects light. There is dust in the air everywhere, even in a room which has just been cleaned and dusted. You can see it when a bright shaft of light enters a darkened room. Every grain of dust reflects the sunlight.

On a clear night the moon looks very bright, but we know it has no light of its own. It reflects the light of the sun. The planets also reflect the sun's light. When the earth moves between the sun and the moon, the earth stops the sunlight from reaching the moon. This is called an eclipse.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? reflection (line 2), grain (line 18), planets (line 21), eclipse (line 24).

2. How does light behave "like ... a ball" (line 6)? *It bounces.*

3. The passage states that without reflection the world would always be dark (lines 11/12). How could this be - the sun would still be shining on it! *See lines 12-14*

4. Draw a diagram to show what the passage means by an eclipse (line 24).

5. Draw a diagram which shows you, the sun, a house and a plane. Draw lines to represents rays of light and show how you see the objects.

6. The sun sets in the west. The moon rises in the east shortly afterwards. How can the moon possibly be seen? Draw a diagram showing the sun, moon and earth and lines to represent rays of light to show why it can be seen.

RESEARCH QUESTIONS

7. What is a periscope? How does it work? Draw a diagram to show how it works. You may show either a prism or mirror periscope.

Hint: the prism uses total internal reflection.

See also exercises B5, B8, B9.

★★

147

RADIOACTIVE JEWELLERY

Doctors have reported several cases of severe skin diseases recently. They have linked these to jewellery made from a particular shipment of gold. This gold contains impurities of radioactive radium.

These impurities come from gold which has been used by doctors. The gold is treated to make it radioactive and then used to treat tumours. Small pellets of the radioactive gold are implanted into the tumours. In some cases, the radiation stops cancer cells from reproducing, or even kills them.

After treatment, the gold is removed from the tumour and treated to remove the radioactive impurities. In this way it can be used again and again.

The gold used in the jewellery appears to be reclaimed metal which was not refined properly. Rings which were examined were found to be radioactive. The emitted between 2 and 290 millirads of radiation per hour. The skin disorders caused by the radiation range from simple rashes, to severe dermatitis, to tumours.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

2,3: Presumably the radium was bound up in the gold to render it chemically inert. In this way, it would affect only the tumour.

1. What do these words mean as they are used in the article?
   linked (line 2), tumour (line 5), implanted (line 6), reclaimed (line 12), dermatitis (line 16).
2. How did the gold become radioactive?
3. Why was the gold made radioactive?
4. How did the radioactive gold get into the jewellery? inadequate refining.
5. The article mentions radium (line 3) as the radioactive substance in the gold. What is radium? Where does it come from? Strictly, a research question.

RESEARCH QUESTIONS

6. Make a list of 5 other radioactive substances. Are they naturally occurring or man-made? How are they obtained? What are they used for?
7. Who first suggested the treatment of tumours using radioactive substances? What radioactive substance was first used in this treatment? What substances are used today?
8. Radioactivity can *cause* cancers, but as the article shows, radioactivity is also used in *treating* them. How is this possible?
   How do doctors arrange that radioactivity is used to kill cancer cells without harming healthy ones?

See also exercises 64 and 66

SOURCE: Life Science Library - "Energy" ★★

Joseph HEAT AND TEMPERATURE 148

James Black, a Scottish chemist was the first man to discover that heat and temperature are not the same thing.

Black placed an iron disc on one burner of a stove and a pan of water of equal mass on another. He heated each for the same amount of time. The iron, after 10 minutes became too hot to touch, while the water was only lukewarm. Equal heat resulted in unequal temperatures. Black concluded that heat is an amount of something, while temperature is the degree of hotness.

Black tested his theory on a number of substances. He found that each one required a different amount of heat to raise its temperature one degree. He called this property of substances "the capacity of heat". Later, scientists arbitrarily assigned the figure "one" as a measure of the heat capacity of water. The ability of other materials to soak up heat, compared to water, is called "specific heat".

Iron, for example, has a specific heat of 0.107. This means it takes only about one tenth as much heat to raise the temperature of iron one degree as it would take to raise of the same mass of water one degree. Strangely enough only two substances have a specific heat greater than that of water, ether (1.041) and ammonia (1.125). This means that water compared with almost every other substance, is slow to absorb heat and slow to lose it.

WHOOPS!

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   chemist (line 1), theory (line 9), property (line 11) arbitrarily (line 12), ability (line 13), mass (line 17)
2. What observation did Black make from this experiment? Lines 5-6
3. What conclusion did Black make from these observations? Lines 7-8
4. Explain the meaning of the sentence Equal heat resulted in unequal temperatures. (line 6).
5. What is "the capacity for heat" (line 11) of a substance?
6. What is the "specific heat" of a substance (line 14)? Line 13
7. Place these substances in decreasing order of specific heat: water, iron, ether, copper, ammonia. Water, iron, copper, ... ether, ammonia we cannot locate *

RESEARCH QUESTIONS

8. Explain the purpose, in an experiment like this, of the equal mass (line 4), equal heat (line 6) and same mass (line 17). Control of extraneous variables
9. The fact that water has a relatively high specific heat has far-reaching consequences to life on earth. Discuss 2 examples of this.

   Try comparing maximum temperatures for Sydney & Liverpool.
10. Why did scientists arbitrarily assign the figure "one" (line 12) to the heat capacity of water? Is this a normal practice for scientists?

    Convenient standard.

from -20°C to 10°C

Aluminium 0.21, copper 0.093, lead 0.032, iron 0.11, ice 0.50, mercury 0.033, ethanol 0.59, turpentine 0.42, glass 0.16

* & for ether is 1.06, and for ammonia it is 1.30.

★★★

149a

FORTY MEN SPEND TWELVE DAYS UNDER THE SEA

The third stage of the U.S. Navy's Man-in-the-Sea program involved putting five diving tanks of eight men each in an under-water habitat known as Sealab III. Sealab III stayed at a depth of 130 metres for 12 days during which time the divers made excursions into the sea.

Sealab III consists of a cylindrical living compartment 3.6 metres in diameter and 17.3 metres long. Two additional rooms 2.4 metres by 3.6 metres are attached to the bottom or hull of the habitat. The forward is an observation and storage compartment with an exit hatch. The after room is a diving station complete with lockers, gear and an open hatch for access to the sea.

The atmopshere in the living compartment is designed for a pressure of 14 Kg per square cm absolute (corresponding to 130m of water) and will contain approximately 92% helium, 6% nitrogen and 2% oxygen. Replenishment gas is piped from the support ship or from external bottles stowed in the habitat. Charcoal is used to remove odours. Heat is supplied by convection heaters and electrical dehumidifiers control the humidity. The temperature is maintained at about 35°C. This would be excessive on the surface but is required in the habitat because of the greater loss of body heat in a helium atmosphere.

Sealab III was supported by a surface ship moored vertically above. The ship had two decompression chambers designed to support four divers. A four-day decompression period was needed to return saturated divers from the pressure at a depth of 130 metres to normal atmospheric conditions. To transport divers from the ship to the bottom of the habitat a pressurised lift was used. This lift mated with the deck compression chambers.

DO NOTE WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   habitat (line 2), replenishment (line 13) saturated (line 21), mated (line 24).

RESEARCH QUESTIONS

2. Draw a longitudinal section (from front to back) of Sealab III labelling as many construction details as possible.
3. What is a convection heater? (line 15) Draw a diagram to show how a convection heater works.
4. What is humidity? (line 16) What is a dehumidifier (line 16)? Explain how a dehumidifier might work.
5. What is a decompression chamber? (Line 20). Explain why a decompression chamber is necessary and how it works.
6. Why is the atmosphere in Sealab III as it is? (line 13). In particular - why so little oxygen?
   - why helium?
   - why so much helium?
7. Why is the pressure in the living compartment maintained at 14 Kg per square cm? (line 11).
8. What is the correct unit of pressure? Convert 14Kg per square cm (line 11) to acceptable units.
9. Explain, possibly with the aid of a diagram, the structure and use, of an open hatch (line 9). If the hatch is open why doesn't the water rush in?

6. The "bends" is also referred to as "caisson disease" - workers under pressure on river beds (in caissons) who were building bridges, were the first victims. A side effect is the "Donald Duck" voice caused by the speed of sound in a helium-rich atmosphere. Lovely physics!

8. One atmosphere ≙ 1 kg/cm² ≙ 100kPa
Approximately 1400kPa
More accurately, 1372 kPa.
(kilopascal)

9. It's underneath and pressurised!

149b

10. Charcoal is used to remove odours (line 15). Explain why this works. See if you can find 5 other situations which use charcoal (or perhaps some other chemicals) to remove (not disguise) odours.

Activated charcoal, often made by heating coconut shells, is a very porous form of charcoal. It absorbs many dyes, poisons and smells, and is used in gasmasks, swimming-pool filters, air conditioners, and (we seem to recall) sugar refining.

"Rome wasn't built in a day" grumbled the worker
"Yes, but I wasn't foreman on that job!" *

★★

WORLD BUILDING RECORD? 150

A 25 metre seven-storey office block was erected in the centre of the German city of Hamburg in 1969, in what may be a record time. In less than three days 346 prefabricated units with a total mass of 25 000 tonnes were assembled to create some 1400 square metres of office space.

This lightning operation was preceded by over a year's preparation of all the necessary component parts of the building. The operation itself began on a Thursday night when a 30 metre crane was erected. The actual office construction began at sunrise on the Friday. Two thirty-man teams, working in shifts, began assembling the prefabricated concrete units. These units were delivered to the site by a shuttle service of trucks in the strict order required and in accordance with a carefully worked out time schedule. Some of the units weighed as much as eight tonnes. They included massive sections of walls, floors, ceilings, pre-cast flights of stairs, lift shafts, and shop fronts complete with neon signs indicating the future tenant. There were even washrooms units complete with toilet, wash basin, mirrors and toilet paper.

The concrete units were fitted together like pieces of a child's construction set. Joints were then welded and cemented over. Work continued at night under floodlights. As soon as each floor was constructed the interior decoration team took over. Therefore, by the time the seventh storey was completed, the lower floors were almost habitable; the walls were painted, lights worked and water came out of taps.

The erection of the building was completed in exactly 65 hours 41 minutes and 23 seconds. The crane was removed again overnight and the traffic flowed again. It has been estimated that it could have taken 5-6 months to build a similar block by conventional methods. It is now possible, therefore, to fill vacant sites in the heart of a busy city quickly and cheaply with the disruptions to traffic and the noise concentrated into a very short time span. In this case it took not much more than one weekend.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   prefabricated (line 3), shuttle (line 10), massive (line 12), conventional (line 26).

2. What organisation had to be done in order for this building operation to run smoothly?

3. What was the major time saving factor in the construction of the building?

4. Can you think of any advantages of constructing buildings by this process? Can you list any disadvantages?

5. Approximately how many prefabricated units must have been assembled per hour? What would be the average time per unit? 5·3

6. What was the *average* mass of each prefabricated unit? What was the mass of the heaviest unit? 72 tonnes

7. If it took over a year's preparation (line 5) and could have been built in 5-6 months by conventional methods (line 26), was time really saved? Explain.

2. Time schedule, and construction of units.

3. Prefabrication - time on site was saved only - see lines 5 & 25

4. Less disruption, but takes longer? less flexibility?

7. See 3, then ask, how much planning time is required for normal construction? Was the work as intense?

* Translated from a papyrus in Linear B, unearthed at Angkor Wat.
Adieu, good friends.
p.m.

Postscripts to Volume Six: the first part of this manual

Annotating material such as this is always a task on which there is more that we could do, but we have to stop somewhere! And so we have. But if we assume that all cross-references should go both ways, there are many references in this part to passages in the first part of the manual. So, on the probably spurious assumption that the references are reflexive, we offer you the following addenda; perhaps you will wish to fill them in in the appropriate places.

PASSAGE	ADDITION
1,2 and 17	Pluto is now inside the orbit of Neptune.
8	See also 127, 128.
9	See also 120, 121, 124.
12	See also 125
13	See also 124
14	See also 126
15	See also 126
17	Pluto does have a moon.
27	See also 89, 118
28	See also 89
29 and 30	See also 89, 131. Lord Snow died in early 1980.
31	On page 74 of the Mentor edition of "The Origin of Species", second page of ch. 3, we find "But the expression often used by Mr. Herbert Spencer of the Survival of the Fittest is more accurate, and is sometimes equally convenient."
33	See also 102, 106, 119.
36	See also 113, 144.
37	See also 102.
39	See also 119.
40	See also 107.
41	See also 106.
42	See also 127, 128.
45	See also 72, 146.
46	See also 72, 146.
48	See also 64, 66, 91, 101.
49	See also 74, 75, 76.
50, 51, 52	See also 118
54 and 55	See also 136, 140.
56	See also 92, 94, 96.
59	See also 87, 130.
60	See also 70, 92, 94, 98, 138.
61	See also 94.
63	See also 64, 65, 66, 68. Details on the steam vehicles appear in the Reading Rigby series: The Car - Friend or Foe, to be published early in 1981. This book may serve as a useful introduction to some of the strange media of communication which lurk in the science text-book; the author is Peter Macinnis (who is not on royalties).

INDEX

Acids 84
Aircraft 128
Algae 23, 44
Alkalis 85
Animal behaviour 34
Antibiotics 56
Ants 33, 106
Aquifer 19, 20
Argentine Ants 33
Artesian water 19, 20, 22
Asbestos 54
Astronomy 1, 2, 3, 4
Atmosphere 8, 83, 132
Atmospheric pressure 13
Atomic energy 81, 134, 135, 137, 138, 139
Atomic structure 77, 78
Atomic theory 73, 75, 77, 78, 79, 80
Avogadro, A. 76
Axolotl 114

Bacteria 40, 56, 107
Barnacles 109
Bats 37, 102
Beast, number of 666
Becquerel 72
Bees 105
Bernoulli effect 65
Biological control 141, 142
Biological time 37
Biology (history) 52
Black, Joseph 66, 148
Blood 98
Bloom, algal 23
Boiling 67, 68
Bone 112
Brunel, I.K. 43
Building, fast 150
Burt, C. 93

Camel 115
Cancer 60, 138
Cape Cod 121
Carbon-14 116
Carburettor 65
Carnot Nicolas 63
Caty 169

Cavendish, Henry 49, 77
Cellulose 86
Chain, Ernst 56
Chemical bonds 73, 79
Chemical properties 24
Chemistry (history) 49, 51
Cholesterol 129
Clock 12
Coasts 120, 121
Colonisation 111
Comets 1, 2
Compass 43
Compounds 80
Condensation 18, 25
Controlled experiments 102
Co-ordination 100
Copper 88
Coral 110
Core of the earth 11
Correlation 138
Coulomb, C.A. 77
Culture and science 29, 30
Cyanides 84, 140

Darwin, Charles 9, 31, 56
Darwin, Francis 56
Deer 38
Deimos 14
Density 14
Desalination 25
Diabetes 97
Dikes 123
Dioxin 55
Disease 54
Diversity of life 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 105, 106, 107, 108, 109, 110, 113, 114, 115, 116, 117.
Duchesne, Augustin 56
Dummy 58
Dust 4

Earth (planet) 11, 12, 125
Earth science 118
Earth's crust 10
Earthworms 108
Echidna 35
Electricity 90
Electromagnetic spectrum 70, 71, 82
Electron 90

Electrostatic charge 18
Elements 74, 78, 80, 88
Energy conversion 69
Energy sources 44, 45, 46
Engineering and science 27
Entomology 33, 101, 103, 104, 105, 106
Entropy 131
Equilibrium 62
Eratosthanes 12
Erosion 9, 120, 121
Escher, M. 133
Evaporation 26
Evolution 31, 39
Expansion 64

Fahrenehit, G. 48
Fish 113, 144
Fleming, Alexander 56
Florey, Howard 56
Flutemouth 144
Fog 18
Force 91
Foreman 150
Fossils 32, 39, 119
Foucault pendulum 12
Fuels 42, 44

Gabon 81
Galileo 48, 125
Gases 49, 75, 76, 83
Gelatin 87
Geology 118
Greek philosophers 75
Ground water 19. 20

Haldane, J.B.S. 12, 34, 125
Halley's Comet 1, 2
Health hazards 40, 54, 55, 136, 137, 138, 139, 140, 147
Health, human 92, 96, 97, 98
Heart disease 98, 129
Heat 64, 66, 131, 148
Heavy water 80
Heimlich manoeuvre 61
Hormones 100
Horned turtle 32
Human evolution 39
Huxley, T.H. 109
Huygens, C. 91

Illiteracy 29, 86
Immunisation 95, 96
Inert gases 83
Infra-red 71
Insects 33, 101, 103, 104, 105, 106
Intelligence 93
Iron 88

Jupiter 17, 125

Kinetic theory 67, 68

Lacewings 142
Latent heat 66
Lavoisier 49, 51, 74
Leeches 16
Leeuwenhoek 107
Leibniz
Life on Jupiter 17
Life science 52
Light 70, 71, 145, 146
Lucerne 105

Magnetism 43
Mariner II 5
Mariner IV 13
Mars 13, 14
Materials 53, 57, 86, 87, 88
Medicine 56, 57, 58, 59, 60, 61. See also Disease, Health
Melanoma 60
Melting 67
Metals 88
Microscopy 107
Molecular biology 30, 52
Molecules 76
Momentum 91, 128
Monotremes 35
Moons, Mars 14
Moons, Saturn 15
Mosquitoes 101
Mountains on Earth 9, 122, 123, 124
Mountains on Mars 13
Mountains on Venus 5
Mushrooms 41
Musical instruments 87

Neptune 17, 126
Newcastle disease
Nomenclature 144
Nuclear energy 134, 135, 137, 138, 139

Oberth, Hermann 45
Ocean bed 10
Orbit 1, 2, 14
Oxygen cycle 132

Packaging 53
Parachutes 42
Pendulum 12
Penicillin 56
Perpetual motion 133
Pesticides 141, 142, 143
Pheromones 104
Philosophy of science, see Science
Phlogiston 49
Phobos 14
Phosphates 23
Physical properties 24
Physics (history) 50
Planet 5, 6, 8, 11, 12, 13, 14, 15, 17
Planets, origin 7
Plants, carnivorous 117
Platypuses 35
Poisons 33, 40, 55, 84, 140
Pollution 23, 47, 53, 60
Polyps 109
Prickly heat 94

Radiation: see Infra-red, Ultra-violet, X-rays, atomic energy
Radioactive decay 134
Rats 143
Reflection 146
Regeneration 114
Reverse reactions 62
Rivers 9
Rome 150

Salinity 21, 25
Salt water 21, 22
Satellites 14, 15, 17, 45, 46, 127
Saturn 15
Sausage skin 130

Science 27. 28, 29, 30, 50, 51, 51, 69, 89
Seeds, old 116
Senses 99, 100, 102, 103
Sewage 23
Shadows 145
Sheepgut 59, 130
Ships 42, 43
Shipwreck 43
Skeleton 112
Skin cancer 60
Smallpox 96
Snow, C.P. 29 30
Social Darwinism 31
Solar energy 45, 46, 72
Solar system: see names of component parts
Solar telescope 3
Space dust 4
Space exploration 5, 8, 16, 127
Spectra 70, 71
Spencer, Herbert 31
Spiny anteaters 35
Spring 19, 20
States of matter 67, 75
Steam engine 63
Sternglass, Ernest 139
Stopping 8, 42, 127
Sugar substitute 129
Sun 3, 60
Sundews 117
Supertankers 42
Surgical tools 57
Survival of the fittest 31
Sutures 59

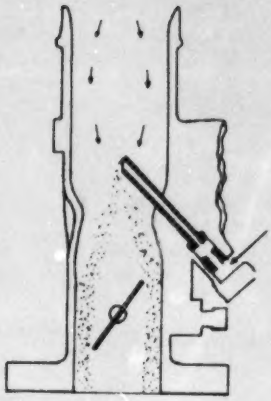
Technology and science 27
Teeth 92
Telescope 3
Temperature 38, 48
Thermodynamics, Second Law 29, 30, 133
Thermometer 48
Toads 34, 104, 141
Toilet paper 47
Toxic gases 40
Transplants 114
Triton 126
Turtles 32
Twins 93
Two cultures 29, 30

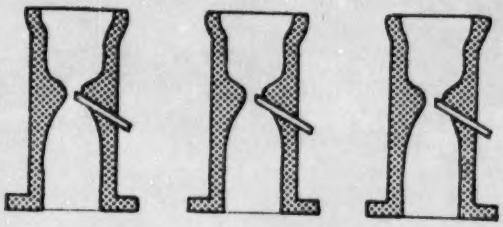
Ultra-violet radiation 70
Uranium 81, 134

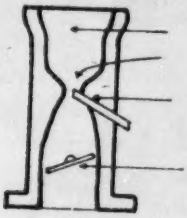
Vaccination 95, 96
Venus 5, 6, 125
Venus' flytrap 117
Verse 115
Virus disease 95, 96
Vitamin C 94
Vitamin D 70
Volcanoes 122, 123

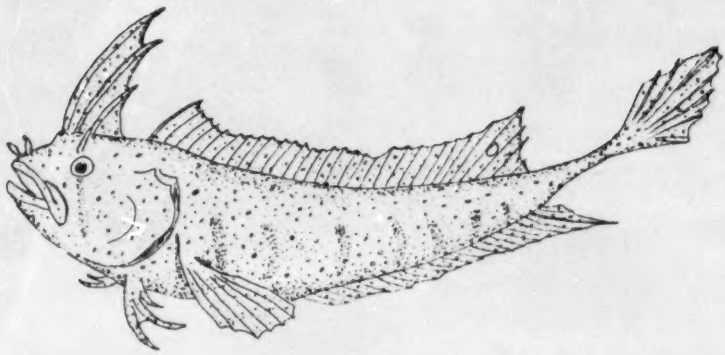
Waste 53
Water 17, 18, 29, 20, 21, 22, 23, 24, 25, 26
Waves 120, 121
Weedfish 113
Whistler's mother 116
Whitley, G.P. 144
Wohler, Friedrich 51
Wombat 36
Writing about science 28

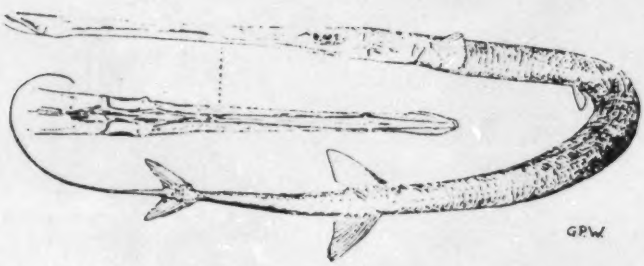
X-rays 82











These diagrams are included to allow you to run off copies for student use on: Exercises 65, 113 and 144.

D. WEST, GOVERNMENT PRINTER, NEW SOUTH WALES—1981